S/N 10/646,359 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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| Applicant: | Schmeichel et al. | Examiner: | Tran |
| Serial No.: | 10/646,359 | Group Art Unit: | 3748 |
| Filed: | August 22, 2003 | Docket No.: | 758.1452USU1 |
| Title: | Apparatus for Emission Control, Systems, and Methods | | |



**DECLARATION OF JULIAN IMES**

I, Julian Imes, depose and say as follows:

1. I am an employee of Donaldson Company, Inc. where my title is Director of Exhaust/Emissions Technology. My responsibilities include the development of diesel engine emissions control retrofit devices and systems. In this role, I am knowledgeable about the governmental regulations concerning diesel engine emissions control retrofits and the technologies that have been utilized by our company and our competitors to meet these governmental regulations for diesel engine emissions control retrofits.

2. The market for diesel engine emissions control retrofits is a competitive and technology-driven market. Some of our competitors in this market include Engelhard, Cleaire, Johnson Matthey, Lubrizol Engine Control Systems, and Extengine.

3. Users of diesel engines generally participate in a diesel engine emissions control retrofit program because of incentives provided by the government or funding provided from the government. Although users of diesel engines generally realize a reduction in emissions from their engines from such retrofits, these diesel engines are usually used in furtherance of a business activity that does not stand to further profit from reductions in emissions. Therefore, users of diesel engines typically perceive emissions control retrofits as a cost to be incurred and minimized as necessary to satisfy the governmental regulations and any incentives. Furthermore,

diesel engine users use their engines for diverse purposes and it is generally very important to such users that the emissions control retrofit system does not impose any additional burden or limitations on their use of the engines.

4. One particular set of governmental regulations concerning diesel engine emissions control retrofits are those issued by the California Air Resources Board ("CARB"). The market in California for diesel engine emissions control retrofits is a particularly important market because of the historical air quality problems there. However, the CARB regulations are also very difficult to satisfy.

5. The CARB regulations governing diesel engine emissions control retrofits appear in the California Code of Regulations, Title 13, Chapter 14, Sections 2700 to 2710. A true and correct copy of these regulations is attached as Appendix A. These regulations define a series of classifications based on the amount of pollution reduction a particular emissions control retrofit strategy attains. For example, a classification of "Level 1" for particulate matter control means that an emissions control retrofit system achieves greater than or equal to a 25 percent reduction in particulate matter. Similarly, "Level 2" requires greater than or equal to a 50 percent reduction in particulate matter and "Level 3" requires greater than or equal to an 85 percent reduction in particulate matter. See Appendix A, page 8. The performance of an emissions control retrofit system must be verified by CARB prior to being sold in California for emissions control retrofits.

6. These classifications for particulate matter control are difficult to satisfy with standard emissions control technologies. According to CARB's website, there are currently only two emissions control retrofit manufacturers whose emission control retrofit systems have been verified by CARB to attain the Level 1 classification for particulate matter control: Donaldson

Company, Inc. and Lubrizol Engine Control Systems. (However, one other system from Cleaire is verified to a separate standard that requires 15 percent or greater reduction of nitrogen oxides.) A true and correct copy of a recent print-out of the relevant page from the CARB website is attached as Appendix B.

7. Donaldson Company's Level 1 emissions control retrofit system incorporates the invention described in the pending patent applications serial numbers 10/704,219 and 10/646,359. A true and correct copy of an Executive Order and a verification letter from CARB describing the Donaldson Company retrofit system and verifying its performance is attached as Application C. The Donaldson Company system includes a Spiracle™ blow-by gas filtration apparatus that filters engine blow-by gases and returns the filtered gases to the engine air intake. Many of the pollutants in the blow-by gas are filtered by the Spiracle™ apparatus, and those that pass through the apparatus are routed to the engine, where they may pass into the exhaust gas. The emissions control retrofit system also includes a exhaust gas treatment device that treats the pollutants in the engine exhaust, which includes those pollutants normally found in the engine exhaust as well as the pollutants that result from recirculating the blow-by gas back into the engine.

8. In the process of developing an emissions control retrofit system to satisfy the Level 1 classification, Donaldson Company found that it was incapable of meeting the requirements with a conventional diesel oxidation catalyst by itself. In attempting to fashion a solution to this problem, Donaldson Company engineers came up with a creative and novel solution. We realized that we could further reduce emissions, and thereby satisfy the retrofit emissions control regulations, by treating the blow-by gas stream in addition to the exhaust gas stream. This was a

profound paradigm shift from conventional approaches to satisfying emissions control retrofit regulations that previously had focused solely on treating the exhaust gas emissions only.

9. The Donaldson Company Level 1 emissions control retrofit system provides significant advantages to diesel engine users over the only other verified Level 1 system for particulate matter control from Lubrizol Engine Control Systems. These advantages include the ability to operate the system with standard diesel fuel that is commonly available. As discussed in a CARB Executive Order, a true and correct copy of which is included as Appendix D, the Lubrizol AZ Purifier™ and AZ Purimuffler™ require, when used with a number of common diesel engines, the use of ultra low sulfur diesel fuel having less than 15 parts per million of sulfur. Fuel satisfying this requirement is not currently widely available, and a system that requires the use of this fuel could be an onerous limitation on the diesel engine user. For example, it may be desired that a truck with a diesel engine be used to cover a wide territory, but the difficulty of finding low sulfur fuel may limit the range of the truck. Moreover, the Donaldson Company system is applicable to a broader range of engines, whereas the Lubrizol system is limited in application to certain engine makes and models.

10. As discussed above, a system from Cleaire is verified to a separate standard that also requires 15 percent or greater reduction of nitrogen oxides. However, this system is applicable only to a single engine model, the "M11" manufactured by Cummins. Furthermore, the Cleaire system involves reprogramming the engine control computer to correct an emissions control defeating device that was the subject of a consent decree between Cummins and other diesel engine manufacturers and the Environmental Protection Agency. See http://epa.gov/compliance/resources/cases/civil/caa/diesel/condec.html, a true and correct copy of which is attached as Appendix F. Unlike the Cleaire system, Donaldson Company's

Level 1 emissions control retrofit system is applicable to a broad range of engines and its performance is unrelated to this emissions control defeating device.

10. One other application for diesel engine emissions control retrofits is the retrofit of diesel engines on school buses in order to reduce the exposure of school children to diesel engine pollution. The Southern Alliance for Clean Energy published a study entitled "A Safer Ride to School: How to Clean Up School Buses and Protect Our Children's Health." A true and correct copy of this study is included in Appendix E. This study evaluated the particulate matter concentrations present within the passenger compartment of a school bus in operation on a bus route. Included in the testing was Donaldson Company's diesel engine emissions control retrofit system according to the invention described in the pending patent applications serial numbers 10/704,219 and 10/646,359, including a Spiracle™ blow-by gas treatment apparatus and an exhaust gas treatment device. The authors of the study stated: "Based on all tests conducted . . ., we conclude that a bus retrofitted with both a DPF [diesel particulate filter] and the Spiracle™ [blow-by gas filtration apparatus] is the only retrofit combination that eliminates ultrafines, $PM_{2.5}$ and black carbon inside the cabin and is the most effective solution to clean up our buses and protect our children's health."

11. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such false statements may jeopardize the validity of the application or any patent issued thereon.

Date: January 18, 2006 By: Julián Imes

Julian Imes

# Final Regulation Order

NOTE: Adopt Title 13, California Code of Regulations, sections 2700 through 2710, to read as follows:

**Chapter 14. Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines**

## § 2700. Applicability

These procedures apply to in-use strategies which, through the use of sound principles of science and engineering, control emissions of particulate matter (PM) and oxides of nitrogen (NOx) from diesel-fueled diesel engines. These strategies may include but are not limited to, diesel particulate filters, diesel oxidation catalysts, fuel additives, selective catalytic reduction systems, exhaust gas recirculation systems, and alternative diesel fuels.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2701. Definitions

(a) The definitions in Section 1900(b), Chapter 1, Title 13 of the California Code of Regulations are incorporated by reference herein. The following definitions shall govern the provisions of this chapter:

(1) "15 ppmw or less sulfur fuel" means diesel fuel with a sulfur content equal to or less than 15 parts per million by weight (ppmw).

(2) "Alternative Diesel Fuel" means any fuel used in diesel engines that is not a reformulated diesel fuel as defined in Sections 2281 and 2282 of Title 13, of the California Code of Regulations, and does not require engine or fuel system modifications for the engine to operate, although minor modifications (e.g. recalibration of the engine fuel control) may enhance performance. Examples of alternative diesel fuels include, but are not limited to, biodiesel, Fischer Tropsch fuels, and emulsions of water in diesel fuel. Natural gas is not an alternative diesel fuel. An emission control strategy using a fuel additive will be treated as an alternative diesel fuel based strategy unless:

(A) The additive is supplied to the vehicle or engine fuel by an on-board dosing mechanism, or

(B) The additive is directly mixed into the base fuel inside the fuel tank of the vehicle or engine, or

(C) The additive and base fuel are not mixed until vehicle or engine fueling commences, and no more additive plus base fuel combination is mixed than required for a single fueling of a single engine or vehicle.

(3) "Applicant" means the entity that has applied for or has been granted verification under this Procedure.

(4) "Auxiliary Emission Control Device" (AECD) means any device or element of design that senses temperature, vehicle speed, engine revolutions per minute (RPM), transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of the emission control system.

(5) "Average" means the arithmetic mean.

(6) "Backpressure Monitor" means a device that includes a sensor for measuring the engine backpressure upstream of a hardware-based diesel emission control system or component thereof installed in the exhaust system and an indicator to notify the operator when the backpressure exceeds specified high and in some cases low backpressure limits, as defined by the engine manufacturer or the applicant for verification of a diesel emission control strategy.

(7) "Baseline" means the test of a vehicle or engine without the diesel emission control strategy implemented.

(8) "Cold Start" means the start of an engine only after the engine oil and water temperatures are stabilized between 68 and 86 degrees F for a minimum of 15 minutes.

(9) "Diesel emission control strategy" or "Diesel emission control system" means any device, system, or strategy employed with an in-use diesel vehicle or piece of equipment that is intended to reduce emissions. Examples of diesel emission control strategies include, but are not limited to, particulate filters, diesel oxidation catalysts, selective catalytic reduction systems, fuel additives used in combination with particulate filters, alternative diesel fuels, and combinations of the above.

(10) "Diesel Emission Control Strategy Family Name." See Section 2706(g)(2).

(11) "Diesel Engine" means an internal combustion engine with operating characteristics significantly similar to the theoretical diesel combustion cycle. The primary means of controlling power output in a diesel cycle engine is by limiting the amount of fuel that is injected into the combustion chambers of the engine. A diesel cycle engine may be petroleum-fueled (i.e., diesel-fueled) or alternate-fueled.

(12) "Durability" means the ability of the applicant's diesel emission control strategy to maintain a level of emissions below the baseline and maintain its physical integrity over some period of time or distance determined by the Executive Officer pursuant to these regulations. The minimum durability testing periods contained herein are not necessarily meant to represent the entire useful life of the diesel emission control strategy in actual service.

(13) "Emergency/Standby Engine" means an internal combustion engine used only as follows: (1) when normal power line or natural gas service fails; or (2) for the emergency pumping of water for either fire protection or flood relief. An engine operated to supplement a primary power source when the load capacity or rating of the primary power source has been either reached or exceeded is not an emergency/standby engine.

(14) "Emission control group" means a set of diesel engines and applications determined by parameters that affect the performance of a particular diesel emission control strategy. The exact parameters depend on the nature of the diesel emission control strategy and may include, but are not limited to, certification levels of engine emissions, combustion cycle, displacement, aspiration, horsepower rating, duty cycle, exhaust temperature profile, and fuel composition. Verification of a diesel emission control strategy and the extension of existing verifications are done on the basis of emission control groups.

(15) "Executive Officer" means the Executive Officer of the Air Resources Board or the Executive Officer's designee.

(16) "Executive Order" means the document signed by the Executive Officer that specifies the verification level of a diesel emission control strategy for an emission control group and includes any enforceable conditions and requirements necessary to support the designated verification.

(17) "Fuel Additive" means any substance designed to be added to fuel or fuel systems or other engine-related systems such that it is present in-cylinder during combustion and has any of the following effects: decreased emissions, improved fuel economy, increased performance of the entire vehicle or one of its component parts, or any combination thereof; or assists diesel emission control strategies in decreasing emissions, or improving fuel economy or increasing performance of a vehicle or component part, or any combination thereof. Fuel additives used in conjunction with diesel fuel may be treated as an alternative diesel fuel. See Section 2701 (a)(2).

"Hot Start" means the start of an engine within four hours after the engine is last turned off. The first hot start test run should be initiated 20 minutes after the cold start for Federal Test Procedure testing following Section 86.1327-90 of the Code of Federal Regulations, Title 40, Part 86.

(19) "Portable Diesel-Fueled Diesel Engine" means a diesel-fueled diesel engine which is designed and capable of being carried or moved from one location to another and does not remain at a single location for more than 12 consecutive months. Engines used to propel mobile equipment or a motor vehicle of any kind are not portable engines. Examples of portable diesel-fueled engine applications include, but are not limited to cranes, pumps, welders, woodchippers, tactical support equipment (military), power generation sets, pile-driving hammers, service or work-over rigs, dredges or boats or barges, and compressors. The definitions in Title 13 California Code of Regulations Section 2452(g) and Section 2452(x) are incorporated by reference herein.

(20) "Regeneration", in the context of diesel particulate filters, means the periodic or continuous combustion of collected particulate matter that is trapped in a particulate filter through an active or passive mechanism. Active regeneration requires a source of heat other than the exhaust itself to regenerate the particulate filter. Examples of active regeneration strategies include, but are not limited to, the use of fuel burners and electrical heaters. Passive regeneration does not require a source of heat for regeneration other than the exhaust stream itself. Examples of passive regeneration strategies include, but are not limited to, the use of fuel additives and the catalyst-coated particulate filter. In the context of NOx reduction strategies, "regeneration" means the desorption and reduction of NOx from NOx adsorbers (or NOx traps) during rich operation conditions.

(21) "Revoke" means to cancel the verification status of a diesel emission control strategy. If a diesel emission control strategy's verification status is revoked by the Executive Officer, the applicant must immediately cease and desist selling the diesel emission control strategy to end-users.

(22) "Stationary Diesel-Fueled Diesel Engine" means either a diesel-fueled diesel engine that is used in a piece of equipment that is designed to remain in one location for the duration of its useful life, or a diesel-fueled diesel engine that is used in a piece of equipment that can be moved from one location to another but remains in a single location for more than 12 consecutive months. Examples of stationary applications include, but are not limited, to electric power generator sets, grinders, rock crushers, sand screeners, cranes, cement blowers, compressors, and water pumps. The definitions in Title 13 California Code of Regulations Section 2452(g) and Section 2452(x) are incorporated by reference herein.

(23) "Verification" means a determination by the Executive Officer that a diesel emission control strategy meets the requirements of this Procedure. This determination is based on both data submitted or otherwise known to the Executive Officer and engineering judgement.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2702. Application Process

(a) Overview. Before submitting a formal application for the verification of a diesel emission control strategy for use with an emission control group, the applicant must submit a proposed verification testing protocol (pursuant to Section 2702(b)) at the Executive Officer's discretion. To obtain verification, the applicant must conduct emission reduction testing (pursuant to Section 2703), durability testing (pursuant to Section 2704), a field demonstration

(pursuant to Section 2705), and submit the results along with comments and other information (pursuant to Sections 2706 and 2707) in an application to the Executive Officer, in the format shown in Section 2702(d). If the Executive Officer grants verification of a diesel emission control strategy, it will issue an Executive Order to the applicant identifying the verified emission reduction and any conditions that must be met for the diesel emission control strategy to function properly. After the Executive Officer grants verification of a diesel emission control strategy, the applicant must provide a warranty, conduct in-use compliance testing of the strategy after having sold or leased a specified number of units, and report the results to the Executive Officer (pursuant to Section 2709). A diesel emission control strategy that employs two or more individual systems or components must be tested and submitted for evaluation as one system. Applicants seeking verification of an alternative diesel fuel must follow the procedure described in Section 2710.

(b) Proposed Verification Testing Protocol. Before formally submitting an application for the initial verification of a diesel emission control strategy, the applicant must submit a proposed verification testing protocol at the Executive Officer's discretion. The Executive Officer shall use the information in the proposed protocol to help determine the need for additional analyses and the appropriateness of allowing alternatives to the prescribed requirements. The protocol should include the following information:
(1) Identification of the contact persons, phone numbers, names and addresses of the responsible party proposing to submit an application.
(2) Description of the diesel emission control strategy's principles of operation. A schematic depicting operation should be included as appropriate.
(3) Preliminary parameters for defining emission control groups that are appropriate for the diesel emission control strategy. The Executive Officer will work with the applicant to determine appropriate emission control group parameters.
(4) The applicant's plan for meeting the requirements of Sections 2703-2706. Existing test data may be submitted for the Executive Officer's consideration. The protocol must focus on verification of the diesel emission control strategy for use with a single emission control group.

(c) If an applicant submits a proposed verification testing protocol, the Executive Officer shall, within 30 days of its receipt, determine whether the applicant has identified an appropriate testing protocol to support an application for verification and notify the applicant in writing that it may submit an application for verification. The Executive Officer may suggest modifications to the proposed verification testing protocol to facilitate verification of the diesel emission control strategy. All applications, correspondence, and reports must be submitted to:

Chief, Heavy-Duty Diesel In-Use Strategies Branch
Air Resources Board
9528 Telstar Avenue
El Monte, CA 91731

(d) Application Format. The application for verification of a diesel emission control strategy must follow the format shown below. If a section asks for information that is not applicable to the diesel emission control strategy, the applicant must indicate "not applicable." If the Executive Officer concurs with the applicant's judgement that a section is not applicable, the Executive Officer may waive the requirement to provide the information requested in that section.

**1. Introduction**

1.1 Identification of applicant, manufacturer, and product

1.2 Identification of type of verification being sought

1.2.1 Description of emission control group selected

1.2.2 Emission reduction claim

**2. Diesel Emission Control Strategy Information**

2.1 General description of the diesel emission control strategy

2.1.1 Discussion of principles of operation and system design

2.1.2 Schematics depicting operation (as appropriate)

2.2 Description of regeneration method

2.2.1 Operating condition requirements for regeneration

2.2.2 Thresholds and control logic to activate regeneration

2.2.3 Description of backpressure monitor including thresholds and control logic

2.3 Favorable operating conditions

2.4 Unfavorable operating conditions and associated reductions in performance

2.5 Fuel requirements and misfueling considerations

2.6 Identification of failure modes and associated consequences

2.7 Complete discussion of potential safety issues *(e.g., uncontrolled regeneration, lack of proper maintenance, unfavorable operating conditions, etc.)*

2.8 Installation requirements

2.9 Maintenance requirements

**3. Alternative Diesel Fuel Information**

3.1 Information from Section 2710(b)

3.2 Emission control group compatibility considerations

3.3 Misfueling prevention strategies

## 4. Diesel Emission Control Strategy and Emission Control Group Compatibility

4.1 Compatibility with the engine
  4.1.1 Discussion on calibrations and design features that may vary from engine to engine
  4.1.2 Effect on overall engine performance
  4.1.3 Effect on engine backpressure
  4.1.4 Additional load on the engine
  4.1.5 Effect on fuel consumption
  4.1.6 Engine oil consumption considerations
4.2 Compatibility with the application
  4.2.1 Dependence of calibration and other design features on application characteristics
  4.2.2 Presentation of typical exhaust temperature profiles and other relevant field-collected data from representative applications within the emission control group
  4.2.3 Comparison of field-collected application data with operating conditions suitable for the diesel emission control strategy

## 5. Testing Information

5.1 Emission reduction testing
  5.1.1 Test facility identification
  5.1.2 Description of test vehicle and engine *(make, model year, engine family name, etc.)*
  5.1.3 Test procedure description *(-pre-conditioning period, test cycle, etc.)*
  5.1.4 Test results and comments
5.2 Durability testing
  5.2.1 Test facility identification
  5.2.2 Description of field application (where applicable)
  5.2.3 Description of test vehicle and engine *(make, model year, engine family name, etc.)*
  5.2.4 Test procedure description *(field or bench, test cycle, etc.)*
  5.2.5 Test results and comments
  5.2.6 Summary of evaluative comments from third-party for in-field durability demonstration *(e.g., driver or fleet operator)*
5.3 Field demonstration (where applicable)
  5.3.1 Field application identification
  5.3.2 Description of test vehicle and engine *(make, model year, engine family name, etc.)*
  5.3.3 Engine backpressure and exhaust temperature graphs with comments
  5.3.4 Summary of evaluative comments from third-party *(e.g., driver or fleet operator)*

## 6. References

7. **Appendices**

A. Laboratory test report information *(for all tests)*
   - A.1 Actual laboratory test data
   - A.2 Plots of engine backpressure and exhaust temperature
   - A.3 Driving traces for chassis dynamometer tests
   - A.4 Quality assurance and quality control information

B. Third-party letters or questionnaires describing in-field performance

C. Diesel emission control system label

D. Owner's manual (as described in Section 2706 (i))

E. Other supporting documentation

(e) Within 30 days of receipt of the application, the Executive Officer shall notify the applicant whether the application is complete.

(f) Within 60 days after an application has been deemed complete, the Executive Officer shall determine whether the diesel emission control strategy merits verification and shall classify it as shown in Table 1:

Table 1. Verification Classifications for Diesel Emission Control Strategies

| Pollutant | Reduction | Classification |
|---|---|---|
| PM | < 25% | Not verified |
| | ≥ 25% | Level 1 |
| | ≥ 50% | Level 2 |
| | ≥ 85%, or ≤ 0.01 g/bhp-hr | Level 3 |
| NOx | < 15% | Not verified |
| | ≥ 15% | Verified in 5% increments |

The applicant and the Executive Officer may mutually agree to a longer time period for reaching a decision, and additional supporting documentation may be submitted by the applicant before a decision has been reached. The Executive Officer shall notify the applicant of the decision in writing and specify the verification level for the diesel emission control strategy and identify any terms and conditions that are necessary to support the verification.

(g) Extensions of an Existing Verification. If the applicant has verified a diesel emission control strategy with one emission control group and wishes to extend the verification to include additional emission control groups, it may apply to do so using the original test data, additional test data, engineering justification and analysis, and any other information deemed necessary by the Executive Officer to address the differences between the emission control

group already verified and the additional emission control group(s). Processing time periods follow sections (e) and (f) above.

(h) Design Modifications. If an applicant modifies the design of a diesel emission control strategy that has already been verified or is under consideration for verification by the Executive Officer, the modified version must be evaluated under this Procedure. The applicant must provide a detailed description of the design modification along with an explanation of how the modification will change the operation and performance of the diesel emission control strategy. To support its claims, the applicant must submit additional test data, engineering justification and analysis, and any other information deemed necessary by the Executive Officer to address the differences between the modified and original designs. Processing time periods follow sections (e) and (f) above.

(i) Treatment of Confidential Information. Information submitted to the Executive Officer by an applicant may be claimed as confidential, and such information shall be handled in accordance with the procedures specified in Title 17, California Code of Regulations, Sections 91000-91022. The Executive Officer may consider such confidential information in reaching a decision on a verification application.

(j) The Executive Officer may lower the verification level or revoke the verification status of a verified diesel emission control strategy family if there are errors, omissions or inaccurate information in the application for verification or supporting information.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2703. Emission Testing Requirements.

(a) The applicant must test the diesel emission control strategy on an emission control group basis and identify the emission control group. The applicant must identify the test engines and vehicles, if applicable, by providing the engine family name, make, model, model year, and PM and NOx certification levels if applicable. The applicant must also describe the applications for which the diesel emission control strategy is intended to be used by giving examples of in-use vehicles or equipment, characterizing typical duty cycles, indicating any fuel requirements, and/or providing other application-related information.

(b) Engine Pre-conditioning. The applicant may tune-up or rebuild test engines prior to, but not after, baseline testing unless rebuilding the engine is an integral part of the diesel emission control strategy. All testing should be performed with the test engine in a proper state of maintenance.

(c) Diesel Emission Control System Pre-conditioning. The engine or vehicle installed with a diesel emission control system must be operated for a break-in period of between 25 and 125 hours before emission testing.

(d) Test Fuel.
  (1) The test fuel must meet the specifications in the California Code of Regulations (Sections 2280 through 2283 of Title 13), with the exception of the sulfur content or other properties previously identified by the applicant and approved by the Executive Officer.
  (2) If operation or performance of a diesel emission control strategy is affected by fuel sulfur content, the sulfur content of the test fuel must be no less than 66 percent of the stated maximum sulfur content for the diesel emission control strategy, unless
    (A) the testing is performed with fuel containing 15 ppmw or less sulfur for verification on 15 ppmw or less sulfur diesel fuel, or
    (B) the testing is performed with diesel fuel commercially available in California for verification on CARB diesel fuel (i.e., fuel meeting the specifications in Title 13, California Code of Regulations, Sections 2280 through 2283).
  (3) Baseline testing may be conducted with commercially available diesel fuel or diesel fuel with 15 ppmw or less sulfur. Baseline and control tests must be performed using the same fuel unless the control fuel is specified as a component of the emission control strategy.
  (4) The test fuel (or batch of fuel purchased) must be analyzed using American Society for Testing and Materials (ASTM) test methods listed in Table 6 (See Section 2710), which are incorporated herein by reference. At a minimum, sulfur content, aromatic content, polycyclic aromatic hydrocarbons, nitrogen content, and cetane number must be reported. The Executive Officer may ask for additional properties to be reported if evidence suggests those properties may affect functioning of the diesel emission control strategy.

(e) Test Cycle. The diesel emission control strategy must be tested using the test cycles indicated in subparagraphs 1-3 below (summarized in Table 2) or with an alternative cycle(s) approved by the Executive Officer pursuant to subsection (f) below.

Table 2. Test Cycles for Emission Reduction Testing*

| Test Type | On-Road | Off-Road (including portable engines) | Stationary |
|---|---|---|---|
| Engine | FTP Heavy-duty Transient Cycle (1 cold-start and 3 hot-starts) | Steady-state test cycle from ARB off-road regulations (3 hot-starts) | Steady-state test cycle from ARB off-road regulations (3 hot-starts) |
| Chassis | UDDS (3 hot-starts) and a low-speed test cycle per 2703 (e)(1)(B)(ii) (3 hot-starts). | Not Applicable | Not Applicable |

* Additional hot-starts are required for NOx emission reductions between 15 to 25 percent (see Section 2703(h)).
FTP = Federal Test Procedure; UDDS = Urban Dynamometer Driving Schedule

(1) On-road Engines and Vehicles. For on-road diesel-fueled vehicles, the applicant may choose between engine dynamometer testing and chassis dynamometer testing, subject to the following conditions. Engine testing may be used for verification of an absolute engine emissions level or a percent emission reduction. Chassis testing may be used only to verify a percent emission reduction. The applicant may use emission test data to satisfy the durability test data requirement, but must follow the same testing option for the remaining durability tests (see Section 2704).

(A) Engine testing must consist of one cold-start and at least three hot-start tests using the Federal Test Procedure (FTP) Heavy-duty Transient Cycle for engines used in on-road applications, in accordance with the provisions in the Code of Federal Regulations, Title 40, Part 86, Subpart N.

(B) The applicant must conduct all chassis tests in accordance with the provisions of the Code of Federal Regulations, Title 40, Part 86, Subpart N insofar as they pertain to chassis dynamometer testing. Chassis testing must include two separate test cycles as follows:

1. At least three hot-start tests using the Urban Dynamometer Driving Schedule (UDDS) (see Code of Federal Regulations, Title 40, Part 86, appendix I (d)).
2. Three hot-start tests using a low-speed chassis test cycle representing urban stop-and-go traffic operation. The test cycle must include a repetitive series of idling periods immediately followed by events of maximum vehicle acceleration. The applicant can propose, for Executive Officer approval, a low-speed cycle as applicable to the type of vehicle and vehicle operation for which the diesel emission control strategy is intended. The Executive Officer

will provide examples (e.g., New York Bus Cycle) of appropriate test cycles upon request by the applicant during the verification process. The applicant may request that the Executive Officer waive the requirement to conduct the low-speed_chassis test. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, characteristics of the duty cycles in the emission control group and the principles of operation of the diesel emission control strategy.

3. The driver must follow the test cycles as closely as possible and must not deviate beyond the following tolerances (See Code of Federal Regulation, Part 86, Subpart M, 86.1215-85).
   (i) The upper limit is 4 miles per hour higher than the highest point on the trace within 1 second of the given time.
   (ii) The lower limit is 4 miles per hour lower than the lowest point on the trace within 1 second of the given time.
   (iii) Speed variations greater than the tolerances (such as may occur during gear changes or braking spikes) are acceptable, provided they occur for less than 2 seconds on any occasion and are clearly documented as to the time and speed at that point of the test cycle.
   (iv) Speeds lower than those prescribed are acceptable, provided the vehicle is operated at maximum available power during such occurrences.

(C) For any diesel emission control strategy intended to reduce NOx from on-road applications, the following requirements apply: (i) The applicant must identify and discuss the effects of elevated NOx emissions on the diesel emission control strategy (emissions of NOx that are significantly greater than certified levels are said to be elevated, and may result, for example, from the activation of an AECD that advances fuel injection timing under cruise conditions). The applicant's discussion must include effects on emission reduction performance, durability, and safety considerations, how the strategy would respond to elevated NOx emissions that do not occur at the time the strategy is calibrated, and must be supported by engineering justification and any pertinent data. (ii) The applicant must perform three hot-start tests with an additional test cycle that gives rise to significant periods of elevated NOx emissions, except as provided below.

1. The applicant may request that the Executive Officer provide assistance with determining an engine or chassis test cycle or may propose a test cycle for approval by the Executive Officer. The Executive Officer will evaluate the proposed test cycle based on its representativeness of real-life operation and consistency with established procedures for determining off-cycle emissions.
2. The applicant may request that the Executive Officer waive the requirement to conduct this additional testing. In reviewing the

request, the Executive Officer may consider all relevant information including, but not limited to, the principles of operation of the diesel emission control strategy and the availability of an appropriate test cycle.

(2) Off-road Engines and Equipment (including portable engines). For off-road diesel-fueled vehicles and equipment, the applicant must follow the steady-state test cycle outlined in the ARB off-road regulations (California Code of Regulations, Title 13, Section 2423 and the incorporated California Exhaust Emission Standards and Test Procedures for New 2000 and Later Off-Road Compression-Ignition Engines, Part I-B). A minimum of three hot-start tests must be conducted for each appropriate test cycle.

(3) Stationary Engines. For stationary engines, the applicant must use the most appropriate off-road test cycle (as referenced in (2) above) representing the operating conditions of the application, with approval from the Executive officer. A minimum of three hot-start tests must be conducted for each appropriate test cycle.

(f) Alternative Test Cycles and Methods. The applicant may request the Executive Officer to approve an alternative test cycle or method in place of a required test cycle or method. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the following:

(1) Similarity of average speed, percent of time at idle, average acceleration, and other characteristics to the specified test cycle or method and in-use duty cycle,

(2) Body of existing test data generated using the alternative test cycle or method,

(3) Technological necessity, and

(4) Technical ability to conduct the required test.

(g) Test Run. The number of tests indicated in Table 2 must be run for both baseline (without the diesel emission control strategy implemented) and control configurations. For strategies that include exhaust aftertreatment, engine backpressure and exhaust temperature must be measured and recorded on a second-by-second basis (1 Hertz) during at least one baseline run and each of the control test runs.

(h) Verification of NOx Emission Reductions. The procedure for verifying NOx reductions depends on the magnitude and nature of the claimed reductions as follows:

(1) For NOx reductions of 25 percent or more below the baseline NOx emissions, the testing protocol described in (e) may be used.

(2) For NOx reductions of less than 25 percent below the baseline NOx emissions, additional hot-start test runs are required to attain equivalent confidence in the results.

(A) For NOx reductions equal to or more than 20 percent, but less than 25 percent, each set of three hot-starts in paragraph (e) above must be augmented to five hot-starts
(B) For NOx reductions equal to or more than 15 percent, but less than 20 percent, each set of three hot-starts in paragraph (e) above must be augmented to nine hot-starts.

(i) Emissions During Particulate Filter Regeneration Events. For any diesel emission control strategy that has a distinct regeneration event, emissions that occur during the event must be measured and taken into account when determining the net emission reduction efficiency of the system. If a regeneration event will not occur during emission testing, applicants may pre-load the diesel emission control system with diesel PM to force such an event to occur during testing, subject to the approval of the Executive Officer. Applicants must provide data or engineering analysis indicating when events occur on test cycles and in actual operation (e.g., backpressure data).

(j) Results. For all valid emission tests used to support emission reduction claims, the applicant must report emissions of total PM, non-methane hydrocarbons or total hydrocarbons (whichever is used for the relevant engine or vehicle certification), oxides of nitrogen, nitrogen dioxide, carbon monoxide, and carbon dioxide.
(1) For mobile sources, or for engines tested using an engine dynamometer, emissions must be reported in grams/mile (g/mile) or grams/brake horsepower-hour (g/bhp-hr).
(2) For stationary engines, gaseous and particulate matter emissions must be reported as required by the test methods approved by the Executive Officer.

(k) Incomplete and Aborted Tests. The applicant must identify all incomplete and aborted tests and explain why those tests were incomplete or aborted.

(l) Additional Analyses. The Executive Officer may require the applicant to perform additional analyses if there is reason to believe that the use of a diesel emission control strategy may result in the increase of toxic air contaminants, other harmful compounds, or a change in the nature or amount of the emitted particulate matter.
(1) In its determination, the Executive Officer may consider all relevant data, including but not limited to the following:
(A) The addition of any substance to the fuel, intake air, or exhaust stream,
(B) Whether a catalytic reaction is known or reasonably suspected to increase toxic air contaminants or ozone precursors,
(C) Results from scientific literature,
(D) Field experience, and
(E) Any additional data.

(2) These additional analyses may include, but are not limited to, measurement of the following:
   (A) Benzene
   (B) 1,3-butadiene
   (C) Formaldehyde
   (D) Acetaldehyde
   (E) Polycyclic aromatic hydrocarbons (PAH)
   (F) Nitro-PAH
   (G) Dioxins
   (H) Furans

(3) The Executive Officer will determine appropriate test methods for additional analyses in consultation with the applicant.

(m) Quality Control of Test Data. The applicant must provide information on the test facility, test procedure, and equipment used in the emission testing. For data gathered using on-road and off-road test cycles and methods, applicants must provide evidence establishing that the test equipment used meets the specifications and calibrations given in the Code of Federal Regulations, Title 40, Part 86, subpart N.

(n) The Executive Officer may, with respect to any diesel emission control strategy sold, leased, offered for sale, or manufactured for sale in California, order the applicant or strategy manufacturer to make available for testing and/or inspection a reasonable number of diesel emission control systems, and may direct that they be delivered at the applicant's expense to the state board at the Haagen-Smit Laboratory, 9528 Telstar Avenue, El Monte, California or where specified by the Executive Officer. The Executive Officer may also, with respect to any diesel emission control strategy being sold, leased, offered for sale, or manufactured for sale in California, have an applicant test and/or inspect a reasonable number of units at the applicant or manufacturer's facility or at any test laboratory under the supervision of the Executive Officer.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2704. Durability Testing Requirements

(a) The applicant must demonstrate, to the satisfaction of the Executive Officer, the durability of the applicant's diesel emission control strategy through an actual field or laboratory-based demonstration combined with chassis or engine dynamometer-based emission tests. If the applicant chooses a laboratory-based durability demonstration, an additional field demonstration will be required to demonstrate in-field compatibility (pursuant to Section 2705). If the applicant has demonstrated the durability of the identical system in a prior verification or has demonstrated durability through field experience, the applicant may request that the Executive Officer accept the previous demonstration in fulfillment of this requirement. In evaluating such a request, the Executive Officer may consider all relevant information including, but not limited to, the similarity of baseline emissions and application duty cycles, the relationship between the emission control group used in previous testing and the current emission control group, the number of engines tested, evidence of successful operation and user acceptance, and published reports.

(b) Engine Selection. Subject to the approval of the Executive Officer, the applicant may choose the engine and application to be used in the durability demonstration. The engine and application must be representative of the emission control group for which verification is sought. The selected engine need not be the same as the engine used for emission testing, but if the applicant does use the same engine, the emission testing may also be used for the initial durability tests.

(c) Test Fuel.
 (1) The test fuel must meet the specifications in the California Code of Regulations (Sections 2280 through 2283 of Title 13), with the exception of the sulfur content or other properties previously identified by the applicant and approved by the Executive Officer.
 (2) If operation or performance of a diesel emission control strategy is affected by fuel sulfur content, the sulfur content of the test fuel must be no less than 66 percent of the stated maximum sulfur content for the diesel emission control strategy, unless
  (A) the testing is performed with fuel containing 15 ppmw or less sulfur for verification on 15 ppmw or less sulfur diesel fuel, or
  (B) the testing is performed with diesel fuel commercially available in California for verification on CARB diesel fuel (i.e., fuel meeting the specifications in Title 13, California Code of Regulations, Sections 2280 through 2283).
 (3) Baseline testing may be conducted with commercially available diesel fuel or diesel fuel with 15 ppmw or less sulfur. Baseline and control tests must be performed using the same fuel unless the control fuel is specified as a component of the emission control strategy.

(4) The test fuel (or batch of fuel purchased) must be analyzed using American Society for Testing and Materials (ASTM) test methods listed in Table 6 (See Section 2710), which are incorporated herein by reference. At a minimum, sulfur content, aromatic content, polycyclic aromatic hydrocarbons, nitrogen content, and cetane number must be reported. The Executive Officer may ask for additional properties to be reported if evidence suggests those properties may affect functioning of the diesel emission control strategy.

(d) Service Accumulation. The durability demonstration consists of an extended service accumulation period in which the diesel emission control strategy is implemented in the field or in a laboratory, with emission reduction testing before and after the service accumulation. Service accumulation begins after the first emission test and concludes before the final emission test. The pre-conditioning period required in Section 2703 (c) cannot be used to meet the service accumulation requirements.

(1) Minimum Durability Demonstration Periods. The minimum durability demonstration periods are shown in Table 3, below. For strategies that include exhaust aftertreatment, engine backpressure and exhaust temperature must be measured and recorded for 1000 hours or over the entire durability period (whichever is shorter). The applicant may propose a sampling scheme for approval by the Executive Officer. The sampling scheme may include, but is not limited to, logging only significant changes in a parameter, averages, or changes above some threshold value. Data must be submitted electronically in columns as a text file or another format approved by the Executive Officer.

Table 3. Minimum Durability Demonstration Periods

| Engine Type | Minimum Durability Demonstration Period |
|---|---|
| On-Road | 50,000 miles or 1000 hours |
| Off-Road (including portable engines) and Stationary | 1000 hours |
| Stationary emergency generator | 500 hours |

(2) Fuel for Durability Demonstrations. The fuel used during durability demonstrations should be equivalent to the test fuel, or a fuel with properties less favorable to the durability of the emission control strategy. Durability demonstrations may, at the applicant's option and with the

Executive Officer's approval, include intentional misfueling events so that data on the effects of misfueling may beobtained.

(e) Third-Party Statement for In-field Durability Demonstrations. For in-field durability demonstrations, the applicant must provide a written statement from an Executive Officer approved third party, such as the owner or operator of the vehicle or equipment used, at the end of the durability period. The statement must describe overall performance, maintenance required, problems encountered, and any other relevant comments. The results of a visual inspection conducted by the third party at the end of the demonstration period must also be described. The description should comment on whether the diesel emission control strategy is physically intact, securely mounted, leaking any fluids, and should include any other evaluative observations.

(f) Test Cycle. Testing requirements are summarized in Table 4. Note that the same cycle(s) must be used for both the initial and final tests.

(1) On-Road Applications. The applicant must perform either chassis or engine dynamometer-based testing before beginning and after completion of the service accumulation as specified in Table 4. A minimum of three hot-start tests are required for chassis testing while a minimum of one cold-start and three hot-start tests are required for engine testing. Chassis testing requires an additional three hot-starts on a low-speed cycle as described in Section 2703(e)(1)(B)2. As indicated in Section 2703(e)(1)(B)2., the applicant may request the Executive Officer to waive the tests on a low-speed cycle. If a field durability demonstration is selected, the applicant must perform chassis dynamometer testing, or request that the Executive Officer consider engine dynamometer testing. In reviewing the request, the Executive Officer may consider all relevant information, including, but not limited to the following:

(A) Similarity of the field vehicle's engine to the laboratory engine, and

(B) Similarity of the diesel emission control system's calibration and set-up when installed on the field vehicle to that when installed on the laboratory engine.

(2) Off-road and Stationary Applications. The applicant must use the same cycle for the emission reduction testing as defined in Section 2703. A minimum of three hot-start tests is required.

(g) Test Run. The requirements for emissions reduction testing are summarized in Table 4, below. The diesel emission control strategy must undergo one set of emission tests before beginning and after completion of the service accumulation . Baseline testing with test repetitions as indicated in Table 4 must be conducted for either the initial test or the final test, but is suggested for both. If there are substantial test data from previous field studies or field demonstrations, applicants may request that the Executive Officer consider these in place of the initial emission tests. For strategies that include exhaust aftertreatment, engine backpressure and exhaust temperature must be

measured and recorded on a second-by-second basis (1 Hertz) during at least one baseline run and each of the control test runs.

Table 4. Emission Tests Required for Durability Demonstrations

| Application | Test Type | Initial Test (prior to service accumulation)<br>Final Test (after completion of 100% of the service accumulation) |
|---|---|---|
| On-Road | Engine | FTP Heavy-duty Transient Cycle<br>(1 cold and 3 hot-starts) |
| | Chassis | UDDS (3 hot-starts) and<br>a low-speed cycle per 2703 (e)(1)(B)2.(3 hot-starts) |
| Off-Road and portable engines | Engine | Steady-state test cycle from ARB off-road regulations or an alternative cycle<br>(3 hot-starts) |
| Stationary | Engine | Steady-state test cycle from ARB off-road regulations or an alternative cycle<br>(3 hot-starts) |

(h) Maintenance During Durability Demonstration. Except for emergency engine repair, only scheduled maintenance on the engine and diesel emission control system and re-fill of additives (if any) may be performed during the durability demonstration. If normal maintenance includes replacement of any component of the diesel emission control system, the time (miles, years, or hours) between component change or refill must be reported with the results of the demonstration.

(i) Performance Requirements. The diesel emission control strategy must meet the following requirements throughout the durability demonstration period:
(1) If the applicant claims a percent emission reduction, the percent emission reduction must meet or exceed the initial verified percent emission reduction level.
(2) If the applicant claims to achieve 0.01 g/bhp-hr for PM, the PM emission level must not exceed 0.01 g/bhp-hr.
(3) The diesel emission control system must maintain its physical integrity. Its physical structure and all of its components not specified for regular replacement during the durability demonstration period must remain intact and fully functional.
(4) The diesel emission control strategy must not cause any damage to the engine, vehicle, or equipment.

(5) The backpressure caused by the diesel emission control strategy should not exceed the engine manufacturer's specified limits, or must not result in any damage to the engine.

(6) No maintenance of the diesel emission control system beyond that specified in its owner's manual will be allowed without prior Executive Officer approval.

(j) Conditional Verification for Off-road and Stationary Applications. If the Executive Officer determines that the diesel emission control strategy is technologically sound and appropriate for the intended application, he may grant a conditional verification for off-road and stationary applications upon completion of 33 percent of the minimum durability period. In making this determination, the Executive Officer may consider all relevant information including, but not limited to, the following: the design of the diesel emission control system, filter and catalyst substrates used, similarity of the system under consideration to verified systems, the intended application of the diesel emission control system, other relevant testing data, and field experience. Where conditional verification is granted, full verification must be obtained by completing the durability testing and all other remaining requirements. These requirements must be completed within a year after receiving conditional verification if laboratory testing is chosen and within three years if field testing is chosen. For the aforementioned time periods, conditional verification is equivalent to verification for the purposes of satisfying the requirements of in-use emission control regulations.

(k) Failure During the Durability Demonstration Period. If the diesel emission control strategy fails to maintain its initial verified percent emission reduction or emission level for any reason, the Executive Officer may downgrade the strategy to the verification level which corresponds to the lowest degraded performance observed in the durability demonstration period. If the diesel emission control strategy fails to maintain at least a 25 percent PM reduction or 15 percent NOx reduction at any time during the durability period, the diesel emission control strategy will not be verified. If the diesel emission control strategy fails in the course of the durability demonstration period, the applicant must submit a report explaining the circumstances of the failure within 90 days of the failure. The Executive Officer may then determine whether to deny verification or allow the applicant to correct the failed diesel emission control strategy and either continue the durability demonstration or begin a new durability demonstration.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2705. Field Demonstration Requirements.

(a) The applicant must demonstrate compatibility of its diesel emission control strategy in the field with at least one vehicle or piece of equipment belonging to the initial emission control group for which it seeks verification. Note that if the durability demonstration selected by the applicant is in-field, it may be used to satisfy the field demonstration requirement for that emission control group.

(1) Compatibility is determined by the Executive Officer based on the third-party statement (see part (c) of this section) and any other data submitted including backpressure data. A diesel emission control strategy is compatible with the chosen application if it:

(A) Does not cause damage to the engine or engine malfunction

(B) Does not cause backpressure outside of the engine manufacturer's specified limits or which results in any damage to the engine

(C) Does not hinder or detract from the vehicle or equipment's ability to perform its normal functions

(D) Is physically intact and well mounted with no signs of leakage or other visibly detectable problems

(2) To determine whether additional emission control groups require separate field demonstrations, the Executive Officer may consider all relevant information, including, but not limited to existing field experience and engineering justification and analysis.

(b) Test Period.

(1) For on- and off-road engines, and stationary engines not used in emergency generators, a vehicle or piece of equipment must be operated with the diesel emission control strategy installed for a minimum period of 200 hours or 10,000 miles, whichever occurs first.

(2) For stationary emergency generators, the emission control system must remain in the field for at least 30 days and operation must include:

(A) 12 maintenance runs (allowing for engine cool down between runs), and

(B) a minimum of two separate 4 hour sessions where the engine is operated under load (allowing engine cool down between runs).

(c) Reporting Requirements.

(1) For strategies that include exhaust aftertreatment, engine backpressure and exhaust temperature must be measured and recorded over the entire demonstration period. The applicant may propose a sampling scheme for approval by the Executive Officer. The sampling scheme may include, but is not limited to, logging only significant changes in a parameter, averages, or changes above some threshold value. Data must be submitted electronically in columns as a text file or another format approved by the Executive Officer.

(2) The applicant must provide a written statement from a third party approved by the Executive Officer, such as the owner or operator of the vehicle or equipment used in the field demonstration. The written statement must be provided at the end of the test period and must describe the following aspects of the field demonstration: overall performance of the test application and the diesel emission control strategy, maintenance performed, problems encountered, and any other relevant information. The results of a visual inspection conducted by the third party at the end of the demonstration period must also be described. The description should comment on whether the diesel emission control strategy is physically intact, securely mounted, leaking any fluids, and should include any other evaluative observations.

(d) Failure During the Field Demonstration. If the diesel emission control strategy fails in the course of the field demonstration, the applicant must submit a report explaining the circumstances of the failure within 90 days of the failure. The Executive Officer may then determine whether to deny verification or allow the applicant to correct the failed diesel emission control strategy and either continue the field demonstration or begin a new field demonstration.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

**§ 2706. Other Requirements.**

(a) Limit and Procedure for Measuring Nitrogen Dioxide ($NO_2$).

(1) The post-control $NO_2$ emissions must not exceed 20 percent of the total baseline (pre-control) NOx emissions on a mass basis, from the same test cycle(s) for emission testing from Section 2703 (e). This limit takes effect beginning on January 1, 2004. Diesel emission control strategies verified and installed prior to January 1, 2004 are exempted from this requirement. Those verified prior to January 1, 2004 will no longer be allowed for installation after January 1, 2004 unless they meet the $NO_2$ emission limit. After January 1, 2004, all diesel emission control strategies verified and installed must meet this requirement.

(2) $NO_2$ emissions are to be quantified by one of the following methods:

(A) Two chemiluminescence analyzers,

(B) A dual-path chemiluminescence analyzer, or

(C) An alternative method approved by the Executive Officer.

(3) For (2)(A) and (2)(B), the analyzers are to be fed from a heated and conditioned sample path. If two chemiluminescence analyzers are employed, they are to be simultaneously fed from a common heated

sample path. One instrument (or path) shall be set to NOx mode, while the second shall be set to nitric oxide (NO) mode. The instrument (or path) set to NOx mode receives a sample that has passed through an $NO_2$-to-NO converter, and the resultant concentration is designated as total NOx ($NO+NO_2$) in the sample. The instrument (or path) that is set to NO mode receives a sample that has not passed through the converter and quantifies the amount of NO only. The difference between NO and NOx is the amount of $NO_2$ in the sample. Both NO and NOx signals are recorded by an external data acquisition system at 1 Hertz. The column data for each NO and NOx signal is then adjusted for time delays that are inherent in both the instruments and the sample paths. Once the data file is aligned, a subtraction of NO from NOx is performed on a second by second basis. The result of this subtraction is then integrated over the entire test run. The result of this integration is the amount of $NO_2$ over the entire test cycle inparts per million (ppm). The equation for calculating total NOx (Code of Federal Regulations, Title 40, part 86, Subpart N) is then used to generate a gram per mile or g/bhp-hr $NO_2$ value. The instrument for measuring NO and NOx must be calibrated in accordance with the NOx calibration procedure as described in the Code of Federal Regulations, Title 40, part 86, Subpart N.

(4) Alternative Method to Measure $NO_2$. The applicant may request the Executive Officer to approve an alternative method in place of the required methods. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the following:
   (A) Correlation of the alternative method with the methods stated in 2(A) or 2(B).
   (B) Body of existing data generated using the alternative method.

(b) Limits on Other Pollutants.
   (1) Limits on non-methane hydrocarbon (NMHC) and NOx. In order for a diesel emission control strategy to be verified, the applicant must comply with one of the following:
      (A)The diesel emission control strategy must not increase the emissions of either NMHC or NOx by more than ten percent of the baseline emissions level as reported under section 2708 (a), or
      (B)For strategies verified prior to July 1, 2006, the applicant must provide sufficient evidence to demonstrate that the sum of NMHC and NOx emissions with the strategy implemented does not exceed the baseline emission level sum of NMHC and NOx as reported under Section 2708 (a); or
      (C) For strategies verified on or after July 1, 2006, the applicant must provide atmospheric modeling data which indicates that widespread use of the strategy will not result in an increase in exposure of the public to ozone. The atmospheric model employed must be approved in advance by the Executive Officer.

(2) Limit on CO. In order for a diesel emission control strategy to be verified, the diesel emission control strategy must not increase the emissions of CO greater than the current CO emission standards for new diesel engines adopted by the Air Resources Board and in effect at the time of verification.

(3) Limit on Ammonia ($NH_3$). In order for a diesel emission control strategy to be verified, the diesel emission control strategy must not increase the emissions of ammonia to a level greater than 25 parts per million by volume on average over any test cycle used to support emission reduction claims.

(A) Emissions of ammonia are to be quantified with a method subject to approval by the Executive Officer which employs Fourier Transform Infrared (FTIR) spectroscopy. The applicant may request the Executive Officer to approve an alternative method in place of the required method. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, consistency with the method required by U.S. EPA and the body of existing data generated using the alternative method.

(B) If an applicant does not expect its diesel emission control strategy to increase emissions of ammonia, the applicant may request that the Executive Officer waive the requirement to conduct testing for ammonia emissions. In reviewing the request, the Executive Officer may consider all relevant information including, but not limited to, the principles of operation of the diesel emission control strategy, the existence of a mechanism for ammonia formation, and published emissions data from similar technologies.

(C) The strategy must be in compliance with applicable federal, state, and local government requirements relating to ammonia emissions, which may be more stringent than the limit presented here.

(4) Other Pollutants. In order for a diesel emission control strategy to be verified, the diesel emission control strategy must not increase the emissions of other pollutants by more than ten percent of the baseline emission level as reported under Section 2708(a).

(c) Fuel Additives. Diesel emission control strategies that use fuel additives must meet the following additional requirements for verification. Fuel additives must be used in combination with a level 3 diesel particulate filter unless they can be proven to the satisfaction of the Executive Officer to be safe for use alone. In addition, the applicant must meet the following requirements:

(1) The applicant must submit the exact chemical formulation of the fuel additive,

(2) Diesel emission control systems employing the dosing of an additive in conjunction with a diesel particulate filter must include an on-board monitor of the additive level in the reservoir, integrated with the diesel particulate filter. The on-board monitor for fuel additive must include indicators to notify the operator when the additive level becomes low and

when the additive tank is empty. In addition, the on-board monitor must be capable of shutting off the supply of additive, if there is a detected diesel particulate filter problem,

(3) The applicant must submit to the Executive Officer environmental, toxicological, epidemiological, and other health-related data pertaining to the fuel additive every two years. The Executive Officer will review the data, including any new information, and may revoke the verification if the data indicate that the fuel additives cause, or are linked, to negative environmental, or health consequences.

(4) The applicant must conduct additional emission tests of fuel additives.

(A) Except as provided in (B) below, the additional emission tests must follow the same test procedures, test cycles, and number of test runs as indicated in Section 2703, except that the concentration of the additive must be at least 50 ppm or 10 times higher than that specified for normal use, whichever is highest. In all other respects, the additive in the high concentration test solutions must be identical to that in the fuel additive submitted for verification.

(B) The applicant may petition to use a concentration less than that required in (A), above, if the higher dose would result in catastrophic damage to the engine. The applicant must supply information on the failure modes, and the level of the additive that would trigger failure. The applicant must also supply information and data supporting the highest feasible dose for testing. An increase in emissions is not by itself sufficient to justify a dose lower than that required in (A), above, and must be correlated to potential engine damage. After reviewing this information and any other relevant information, the Executive Officer shall determine if testing at a lower level could be accepted, or if testing must be conducted at 50 ppm or ten times the specified dose rate as required in (A).

(5) Fuel additives must be in compliance with applicable federal, state, and local government requirements. This requirement includes, but is not limited to, registration of fuel additives with the U.S. EPA.

(d) Engine Backpressure and Monitoring. During the emission and durability testing, the applicant must demonstrate that the backpressure caused by its diesel emission control system is within the engine manufacturer's specified limits, or will not result in any damage to the engine. Furthermore,

(1) If operation of the engine with the diesel emission control system installed will result in a gradual build-up of backpressure exceeding the engine's specified limits over time (such as due to the accumulation of ash in a filter), information describing how the backpressure will be reduced must be included.

(2) All filter-based diesel emission control systems must be installed with a backpressure monitor to notify the operator when the high backpressure limit, as specified by the engine manufacturer or included in the

verification, is approached. The applicant must identify the high backpressure limits of the system in its application for verification.

(3) The Executive Officer reserves the right to require monitors that identify low backpressure limits in those cases where failures leading to low backpressure are unlikely to be detected, or have the potential to cause environmental damage beyond that caused by the engine prior to being equipped with the emission control strategy (e.g., systems that introduce additives into the fuel).

(e) Fuel and Oil Requirements. The applicant must specify the fuel and lubricating oil requirements necessary for proper functioning of the diesel emission control system. The applicant must also specify any consequences that will be caused by failure to comply with these requirements, as well as methods for reversing any negative consequences.

(f) Maintenance Requirements. The applicant must identify all normal maintenance requirements for the diesel emission control system. The applicant must specify the recommended intervals for cleaning and/or replacing components. Any components to be replaced within the defects warranty period must be covered with the original diesel emission control system package or provided free of charge to the customer at the appropriate maintenance intervals. Any normal maintenance items that the applicant does not intend to provide free of charge must be approved by the Executive Officer (the applicant is not required to submit cost information for these items). In addition, the applicant must specify procedures for proper handling of spent components and/or materials cleaned from the diesel emission control system. If any such materials are hazardous, the applicant must identify them as such in the owner's manual. For filter-based diesel emission control strategies, the applicant must include procedures for resetting any backpressure monitors after maintenance procedures are completed.

(g) System Labeling.

(1) The applicant must ensure that a legible and durable label is affixed on both the diesel emission control system and the engine on which the diesel emission control system is installed except as noted in (3) below. The required labels must identify the name, address, and phone number of the manufacturer, the diesel emission control strategy family name (defined in (2) below), a unique serial number, and the month and year of manufacture. The month and year of manufacture are not required on the label if this information can be readily obtained from the applicant by reference to the serial number. A scale drawing of a sample label must be submitted with the verification application. Unless an alternative is approved by the Executive Officer, the label information must be in the following format:

**Name, Address, and Phone Number of Manufacturer**
**Diesel Emission Control Strategy Family Name**
**Product Serial Number**
**ZZ-ZZ** (Month and Year of manufacture, e.g., 06-02)

(2) Diesel Emission Control Strategy Family Name. Each diesel emission control strategy shall be assigned a family name defined as below:

**CA/MMM/YYYY/PM#/N##/APP/XXXXX**

| | |
|---|---|
| CA: | Designates a diesel emission control strategy verified in California |
| MMM: | Manufacturer code (assigned by the Executive Officer) |
| YYYY: | Year of verification |
| PM#: | PM verification level 1, 2, or 3 (e.g., PM3 means a level 3 PM emission control system). |
| N##: | NOx verified reduction level in percent, if any (e.g., N25 means NOx reduction of 25 percent). |
| APP: | Verified application which may include a combination of On-road (ON),Off-road (OF),or Stationary (ST) |
| XXXXX: | Five alphanumeric character code issued by the Executive Officer |

(3) The applicant may request that the Executive Officer approve an alternative format or waive the requirement to affix a label to the diesel emission control system or engine as described in this section. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the informational content of an alternative label as proposed by the applicant.

(h) Additional Information. The Executive Officer may require the applicant to provide additional information about the diesel emission control strategy or its implementation when such information is needed to assess environmental impacts associated with its use.

(i) Owner's Manual. The applicant must provide a copy of the diesel emission control system owner's manual, which must clearly specify at least the following information:

(1) Warranty statement including the warranty period over which the applicant is liable for any defects.
(2) Installation procedure and maintenance requirements for the diesel emission control system.
(3) Possible backpressure range imposed on the engine.
(4) Fuel consumption penalty, if any.
(5) Fuel requirements including sulfur limit, if any.
(6) Handling and supply of additives, if any.

(7) Instructions for reading and resetting the backpressure monitor.
(8) Requirements for lubrication oil quality and maximum lubrication oil consumption rate.
(9) Contact information for replacement components and cleaning agents.
(10) Contact information to assist an end-user to determine proper ways to dispose of waste generated by the diesel emission control strategy (e.g., ash accumulated in filter-based systems). At a minimum, the owner's manual should indicate that disposal must be in accordance with all applicable Federal, State and local laws governing waste disposal.

(j) Noise Level Control. Any diesel emission control system that replaces a muffler must continue to provide at a minimum the same level of exhaust noise attenuation as the muffler with which the vehicle was originally equipped by the vehicle or engine manufacturer. Applicants must ensure that the diesel emission control system complies with all applicable noise limits contained in Part 205, Title 40, Code of Federal Regulations and California Vehicle Code, Sections 27150, 27151 and 27200 through 27207, for the gross vehicle weight rating and year of manufacture of the vehicle for which the diesel emission control strategy is intended. All diesel emission control systems must be in compliance with applicable local government requirements for noise control.

(k) Multimedia Assessment for Fuel Strategies. Diesel emission control strategies which rely on fuel changes either through use of additives or through use of alternative diesel fuels must undergo an evaluation of the multimedia effects. No diesel emission control strategy that relies on the use of an additive or an alternative fuel may be verified unless a multimedia evaluation of the additive or alternative fuel has been conducted and the California Environmental Policy Council established by Public Resources Code section 71017 has determined that such use will not cause a significant adverse impact on the public health or the environment, pursuant to Health and Safety Code section 43830.8. No person shall sell, offer for sale, supply or offer for supply an alternative fuel or a diesel fuel in California that contains an additive for use in a verified diesel emission control strategy unless such a multimedia evaluation has been conducted and resulted in a determination that use of the alternative fuel or additive will not cause a significant adverse impact on the public health and the environment. The applicant shall bear the expense of conducting the multimedia assessment.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, 43830.8, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, 43204-43205.5, and 43830.8 Health and Safety Code; Section 71017 Public Resources Code; Title 17 of Regulations Section 93000.

## § 2707. Warranty Requirements.

(a) (1) Product Warranty.

(A) The applicant must warrant to all owners, for ownership within the warranty period and lessees, for lease contract within the warranty period, that its verified diesel emission control strategy is free from defects in design, materials, workmanship, or operation of the diesel emission control strategy which cause the diesel emission control strategy to fail to conform to the emission control performance level it was verified to, or to the other requirements of Sections 2700-2706, and 2710 for the minimum periods shown in Table 5, provided the operation of and conditions of use for the vehicle, equipment, engine, and diesel emission control strategy conform with the operation and conditions specified in the ARB's Executive Order.

(B) For each engine type and size listed in Table 5, the minimum defects warranty period is terminated by that listed event which occurs first. The warranty must cover the full repair or replacement cost of the diesel emission control strategy, including parts and labor.

(C)The warranty must also cover the full repair or replacement to return the vehicle, equipment, or engine components to the condition they were in prior to the failure, including parts and labor, for damage to the engine or other vehicle components proximately caused by the verified diesel emission control strategy. Repair or replacement of any warranted part, including the engine and other parts, must be performed at no charge to the vehicle or engine owner. This includes only those relevant diagnostic expenses in the case in which a warranty claim is valid. The applicant may, at its option, instead pay the fair market value of the vehicle, equipment, or engine prior to the time the failure occurs.

(D)The repair or replacement of any warranted part otherwise eligible for warranty coverage, may be excluded from such warranty coverage at the applicant's discretion if the applicant demonstrates that the diesel emission control strategy, vehicle or engine has been abused, neglected, or improperly maintained, and that such abuse, neglect, or improper maintenance was the direct cause of the need for the repair or replacement of the part.

(E) Failure of the vehicle or engine owner to ensure scheduled maintenance or to keep maintenance records for the vehicle, equipment, engine, or diesel emission control strategy may, but shall not per se, be grounds for disallowing a warranty claim.

(2) Installation Warranty

(A) A person or company who installs a verified diesel emission control strategy must warrant that the installation is free from defects in workmanship or materials which cause the diesel emission control

strategy to fail to conform to the emission control performance level it was verified to or the other requirements of sections 2700-2706 for the minimum time periods shown in Table 5.

(B) For each engine type and size listed in Table 5, the minimum defects warranty period is terminated by that listed event whichever occurs first. The extent of the warranty coverage provided by installers must be the same as the warranty provided by the applicant as established in subsection (a)(1) and the same exclusions must apply.

Table 5. Minimum Warranty Periods

| Engine Type | Engine Size | Minimum Warranty Period |
|---|---|---|
| On-Road | Light heavy-duty, 70 to 170 hp, Gross Vehicle Weight Rating (GVWR) less than 19,500 lbs. | 5 years or 60,000 miles |
| | Medium heavy-duty, 170 to 250 hp, GVWR from 19,500 lbs. to 33,000 lbs. | 5 years or 100,000 miles |
| | Heavy heavy-duty, exceeds 250 hp, GVWR exceeds 33,000 lbs. | 5 years or 150,000 miles |
| Off-Road (includes portable engines) and Stationary | Under 25 hp, and for constant speed engines rated under 50 hp with rated speeds greater than or equal to 3,000 rpm | 3 years or 1,600 hours |
| | At or above 25 hp and under 50 hp | 4 years or 2,600 hours |
| | At or above 50 hp | 5 years or 4,200 hours |

(b)(1) Product Warranty Statement. The applicant must furnish a copy of the following statement in the owner's manual.

YOUR WARRANTY RIGHTS AND OBLIGATIONS

(Applicant's name) must warrant the diesel emission control system in the application for which it is sold or leased to be free from defects in design, materials, workmanship, or operation of the diesel emission control system which cause the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706, and 2710, for the periods of time listed below, provided there has been no abuse, neglect, or improper maintenance of your diesel emission control system, vehicle or equipment, as specified in the owner's manuals. Where a warrantable condition exists, this warranty also covers other vehicle or equipment parts from damage caused by the diesel emission control system, subject to the same exclusions for abuse, neglect or improper maintenance of your vehicle or equipment. Please review your owner's manual for other

warranty information. Your diesel emission control system may include a core part (e.g., particulate filter, diesel oxidation catalyst, selective catalytic reduction converter) as well as hoses, connectors, a back pressure monitor (if applicable), and other emission-related assemblies. Where a warrantable condition exists, (applicant's name) will repair or replace your diesel emission control system at no cost to you including diagnosis, parts, and labor.

WARRANTY COVERAGE:

For a (engine size) engine used in a(n) (type of application) application, the warranty period will be (years or hours or miles of operation) whichever occurs first. If any emission-related part of your diesel emission control system is defective in design, materials, workmanship, or operation of the diesel emission control system thus causing the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706, and 2710, within the warranty period, as defined above, (Applicant's name) will repair or replace the diesel emission control system, including parts and labor

In addition, (applicant's name) will replace or repair the vehicle, equipment, or engine components to the condition they were in prior to the failure, including parts and labor, for damage to the engine or other vehicle components proximately caused by the verified diesel emission control strategy. This also includes those relevant diagnostic expenses in the case a warranty claim is valid. (Applicant 's name) may, at its option, instead pay the fair market value of the vehicle, equipment, or engine prior to the time the failure occurs.

OWNER'S WARRANTY RESPONSIBILITY

As the (vehicle, engine, equipment) owner, you are responsible for performing the required maintenance described in your owner's manual. (Applicant's name) recommends that you retain all maintenance records and receipts for maintenance expenses for your vehicle, engine, or equipment, and diesel emission control system. If you do not keep your receipts or fail to perform all scheduled maintenance, (applicant's name) may have grounds to deny warranty coverage. You are responsible for presenting your vehicle, equipment, or engine, and diesel emission control system to a (applicant's name) dealer as soon as a problem is detected. The warranty repair or replacement should be completed in a reasonable amount of time, not to exceed 30 days. If a replacement is needed, this may be extended to 90 days should a replacement not be available, but must be performed as soon as a replacement becomes available.

If you have questions regarding your warranty rights and responsibilities, you should contact (Insert chosen applicant's contact) at 1-800-xxx-xxxx or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731, or (800) 363-7664, or electronic mail: helpline@arb.ca.gov.

(b)(2) Installation Warranty Statement. The installer must furnish the owner with a copy of the following statement.

YOUR WARRANTY RIGHTS AND OBLIGATIONS

(Installer's name) must warrant that the installation of a diesel emission control system is free from defects in workmanship or materials which cause the diesel emission control system to fail to conform to the emission control performance level it was verified to, or to the requirements in the California Code of Regulations, Title 13, Sections 2700 to 2706. The warranty period and the extent of the warranty coverage provided by (installer's name) must be the same as the warranty provided by the product manufacturer, and the same exclusions must apply.

OWNER'S WARRANTY RESPONSIBILITY

As the vehicle, engine, or equipment owner, you are responsible for presenting your vehicle, engine, or equipment, and diesel emission control system to (installer's name) as soon as a problem with the installation is detected.

If you have questions regarding your warranty rights and responsibilities, you should contact (Insert chosen installer's contact) at 1-800-xxx-xxxx or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731, or (800) 363-7664, or electronic mail: helpline@arb.ca.gov.

(c) Diesel Emission Control Strategy Warranty Report. The applicant must submit a warranty report to the Executive Officer by February 1 of each calendar year. The applicant must also submit a warranty report within 30 calendar days if warranty claims exceed four percent of the number of diesel engines using the diesel emission control strategy. The warranty report must include the following information:
- (1) Annual and cumulative sales, and annual and cumulative leases of diesel emission control systems (California only).
- (2) Annual and cumulative production of diesel emission control systems (California only).
- (3) Annual summary of warranty claims (California only). The summary must include:
  - (A) A description of the nature of the claims and of the warranty replacements or repairs. The applicant must categorize warranty claims for each diesel emission control strategy family by the component(s) replaced or repaired.
  - (B) The number and percentage of diesel emission control systems of each model for which a warranty replacement or repair was identified.
  - (C) A short description of the diesel emission control system component that was replaced or repaired under warranty and the most likely reason for its failure.

(4) Date the warranty claims were filed and the engine family and application the diesel emission control systems were used with.
(5) Delineate the reason(s) for any instances in which warranty service is not provided to end-users that file warranty claims.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

**§ 2708. Determination of Emissions Reduction.**

(a) Calculation of Emissions Reduction. The emissions reduction verified for a diesel emission control strategy is based on the average of all valid test results before (baseline) and after (control) implementation of the diesel emission control strategy. Test results from both emission testing and durability testing are to be used. If the applicant chooses to perform either the initial or the final durability baseline test, but not both, it must use those results to calculate the reductions obtained in both the initial and final control tests.

(1) Percentage Reduction. The percentage reduction for a given pair of baseline and control test sets (where a "set" consists of all test cycle repetitions, e.g., the test set of 3 hot-start UDDS tests) is the difference between the average baseline and average control emissions divided by the average baseline emissions, multiplied by 100 percent. The average of all such reductions, as shown in the equation below, is used in the verification of a diesel emission control strategy.

$$\text{Percentage Reduction} = 100\% \times \frac{\Sigma\,[(\text{baseline}_{AVG} - \text{control}_{AVG})/\text{baseline}_{AVG}]}{\text{Number of control test sets}}$$

Where:

$\Sigma$ = sum over all control test sets

$\text{baseline}_{AVG}$ or $\text{control}_{AVG}$ = average of emissions from all baseline or control test repetitions within a given set

(A) For any test set involving cold and hot starts, the time weighted emission result is to be calculated by weighting the cold-start emissions by one-seventh (1/7) and the hot-start emissions by six-sevenths (6/7) as shown below.

Weighted Emission Result = 1/7* average cold-start emissions +
6/7* average hot-start emissions

(B) For applicants seeking verification of NOx reductions from on-road applications, weighted test results from the additional test set described in subsection 2703(e)1(C) are included in the percentage reduction equation above. The Executive Officer shall determine an appropriate weighting factor in consultation with the applicant based on factors including, but not limited to, the amount of time that vehicles within the selected emission control group have elevated NOx emissions and the breadth of engines and applications encompassed by the emission control group.

(2) The absolute emission level is the average control emission level, as defined in the following equation:

$$\text{Absolute Emission Level} = \frac{\Sigma(\text{control}_{AVG})}{\text{Number of control test sets}}$$

(b) Categorization of the Diesel Emission Control Strategy. The Executive Officer shall categorize diesel emission control strategies to reduce PM and NOx emissions based on their verified emission reductions. Diesel emission control strategies that reduce NOx will be assigned their verified emission reduction in five percent increments. Diesel emission control strategies are categorized by their PM reductions as follows:

(1) Level one: the system has been demonstrated under these procedures to reduce PM emissions by at least 25 percent from the baseline emission level.

(2) Level two: the system has been demonstrated under these procedures to reduce PM emissions by at least 50 percent from the baseline emission level.

(3) Level three: the system has been demonstrated under these procedures to reduce PM emissions by at least 85 percent from the baseline emission level, or to achieve PM emission levels of 0.01 grams per brake-horsepower-hour (g/bhp-hr) or less.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2709. In-Use Compliance Requirements

(a) Applicability. These in-use compliance requirements apply to all diesel emission control strategies for on-road, off-road, and stationary applications. It is the responsibility of the applicant to perform in-use compliance testing for each verified diesel emission control strategy family (see Section 2706(g)(2)). Testing is required when 50 units within a given diesel emission control strategy family have been sold or leased in the California market. Applicants must submit an in-use compliance testing proposal for approval by the Executive Officer prior to the in-use compliance testing.

(b) Test Phases. In-use compliance testing, as described below in (c), (d), and (e), must be conducted at two different phases for each diesel emission control strategy family:
  (1) Phase 1. Applicants must obtain and test diesel emission control systems once they have been operated for at least one year or within three months of their first maintenance, whichever comes first.
  (2) Phase 2. Applicants must obtain and test diesel emission control systems once they have been operated between 60 and 80 percent of their minimum warranty period.

(c) Selection of Diesel Emission Control Systems for Testing. For each diesel emission control strategy family and for both test phases, the Executive Officer will identify a representative sample of engines or vehicles equipped with diesel emission control systems for in-use compliance testing. The engines or vehicles equipped with the selected diesel emission control systems must have good maintenance records and may receive a tune-up or normal maintenance prior to testing. The applicant must obtain information from the end users regarding the accumulated mileage or hours of usage, maintenance records (to the extent practicable), operating conditions and a description of any unscheduled maintenance that may affect the emission results.

(d) Number of Diesel Emission Control Systems to be Tested. The number of diesel emission control systems an applicant must test in each of the two test phases will be determined as follows:
  (1) A minimum of four diesel emission control systems in each diesel emission control strategy family must be tested. For every system tested that does not reduce emissions by at least 90 percent of the lower bound of its initial verification level (or does not achieve an emission level less than or equal to 0.011 g/bhp-hr of PM), two more diesel emission control systems from the same family must be obtained and tested. The total number of systems tested shall not exceed ten per diesel emission control strategy family.
  (2) At the discretion of the Executive Officer, applicants may begin by testing more than the minimum of four diesel emission control systems. Applicants may concede failure of an emission control system before testing a total of ten diesel emission control systems.

(e) In-use Compliance Emission Testing. Applicants must follow the testing procedure used for emission reduction verification as described in Section 2703 (both baseline and control tests are required). In addition, applicants must select the same test cycle(s) that they used to verify the diesel emission control strategy originally. If a diesel emission control strategy verified by U.S. EPA must perform engine dynamometer testing with the Heavy-duty Transient FTP cycle to fulfill the in-use compliance requirements of that program, but was verified by the Executive Officer with chassis dynamometer testing, the Executive Officer will also accept testing with the Heavy-duty Transient FTP cycle for the in-use compliance requirements of this Procedure. If a diesel emission control strategy fails catastrophically during the in-use compliance testing, the applicant must provide an investigative report detailing the causes of the failure to the Executive Officer within 90 days of the failure.

(f) The Executive Officer may approve an alternative to the in-use testing described above, on a case by case basis, if such testing is overly burdensome to either the applicant or to the end-users due to the nature of the industry the particular diesel emission control systems are used in. The proposed alternative must use scientifically-sound methodology and be designed to determine whether the diesel emission control strategy is in compliance with the emission reductions the Executive Officer verified it to.

(g) The Executive Officer may, with respect to any diesel emission control strategy sold, leased, offered for sale, or manufactured for sale in California, order the applicant or strategy manufacturer to make available for compliance testing and/or inspection a reasonable number of diesel emission control systems, and may direct that they be delivered at the applicant's expense to the state board at the Haagen-Smit Laboratory, 9528 Telstar Avenue, El Monte, California or where specified by the Executive Officer. The Executive Officer may also, with respect to any diesel emission control strategy being sold, leased, offered for sale, or manufactured for sale in California, have an applicant compliance test and/or inspect a reasonable number of units at the applicant or manufacturer's facility or at any test laboratory under the supervision of the ARB Executive Officer.

(h) In-Use Compliance Report. The applicant must submit an in-use compliance report to the Executive Officer within three months of completing each phase of testing. The following information must be reported for each of the minimum of four diesel emission control systems tested:

(1) Parties involved in conducting the in-use compliance tests.
(2) Quality control and quality assurance information for the test equipment.
(3) Diesel emission control strategy family name and manufacture date.

(4) Vehicle or equipment and type of engine (engine family name, make, model year, model, displacement, etc.) the diesel emission control system was applied to.
(5) Estimated mileage or hours the diesel emission control system was in use.
(6) Results of all emission testing.
(7) Summary of all maintenance, adjustments, modifications, and repairs performed on the diesel emission control system.

(i) The Executive Officer may request the applicant to perform additional in-use testing if the warranty claims exceed four percent of the number of diesel engines using the diesel emission control strategy, or based on other relevant information. As noted in Section 2707(c), if warranty claims exceed four percent of the number of diesel engines using the diesel emission control strategy, the applicant must notify the Executive Officer and submit a warranty report within 30 calendar days of that time.

(j) Conditions for Passing In-Use Compliance Testing. For a diesel emission control strategy to pass in-use compliance testing, emission test results must indicate that the strategy reduced emissions by at least 90 percent of the lower bound of the emission reduction level the Executive Officer originally verified it to. If the first four diesel emission control systems tested within a diesel emission control strategy family meet this standard, the diesel emission control strategy passes in-use compliance testing. If any of the first four diesel emission control systems tested within a diesel emission control strategy family fail to reduce emissions by at least 90 percent of the lower bound of the emission reduction level the Executive Officer originally verified it to, and more than four units are tested, at least 70 percent of all units tested must pass the 90 percent standard for the diesel emission control strategy family to pass in-use compliance testing. For each failed test, for which the cause of failure can be attributed to the product and not to maintenance or other engine-related problems, two additional units must be tested, up to a total of ten units per diesel emission control strategy family.

(k) Failure of In-use Compliance Testing. If a diesel emission control strategy family does not meet the minimum requirements for compliance, the applicant must submit a remedial report within 90 days after the in-use compliance report is submitted. The remedial report must include:
(1) Summary of the in-use compliance report.
(2) Detailed analysis of the failed diesel emission control systems and possible reasons for failure.
(3) Remedial measures to correct or replace failed diesel emission control systems as well as the rest of the in-use diesel emission control systems.

(l) The Executive Officer may evaluate the remedial report, annual warranty report, and all other relevant information to determine if the diesel emission control strategy family passes in-use compliance testing. The Executive

Officer may request more information from the applicant. Based on this review, the Executive Officer may lower the verification level or revoke the verification status of a verified diesel emission control strategy family. The Executive Officer may also lower the verification level or revoke the verification status of a verified diesel emission control strategy family, if the applicant does not conduct in-use compliance testing in accordance with this section, or if the Executive Officer conducts in-use compliance testing in accordance with this section (including alternative testing) and the diesel emission control strategy family does not pass the standards in this section.

(m) The Executive Officer may lower the verification level or revoke the verification status of a verified diesel emission control strategy family if the applicant fails to observe the requirements of Sections 2706 or 2707. The Executive Officer must allow the applicant an opportunity to address the possible lowering or revocation of the verification level in a remedial report to the Executive Officer and the Executive Officer may make this determination based on all relevant information.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, and 43204-43205.5 Health and Safety Code; Title 17 California Code of Regulations Section 93000.

## § 2710. Verification of Emission Reductions for Alternative Diesel Fuels

(a) Applicability. This section applies to in-use strategies that include emission reductions from the use of alternative diesel fuels.. The requirements in this section are in addition to those in Sections 2700-2709, except as specifically noted.

(b) Alternative Diesel Fuel Proposed Test Protocol. The applicant must submit a proposed test protocol which includes:

(1) References to criteria pollutant and toxic emissions sampling and analyses that are consistent with the requirements of Section 2703.

(2) Description and Parameters of Alternative Diesel Fuels.

(A) The applicant must describe the applicability of the alternative diesel fuel to diesel engines and identify any requirements for engine or fuel system modifications.

(B) The applicant must provide a general description of the alternative diesel fuel that includes the fuel type, fuel characteristics, fuel properties, fuel formulation, and chemical composition. The applicant for the candidate alternative diesel fuel must specify the following:

1. Identity, chemical composition, and concentration of fuel additives
2. Sulfur content

3. Total aromatic content
4. Total polycyclic aromatic hydrocarbon content
5. Nitrogen content
6. API gravity (density)
7. Distillation temperature distribution information, initial boiling point (IBP),
8. 10% recovered (REC), 5O% REC, 90% REC, and end point (EP)

(C) The applicant must provide information on the candidate alternative diesel fuel that may affect engine performance, engine wear, and safety. The applicant for the candidate alternative diesel fuel must specify the following:

1. Viscosity (engine performance)
2. Fuel volatility (engine performance)
3. Ignition quality (engine performance)
4. Fuel operating temperatures (engine performance)
5. Engine wear tendencies (engine wear)
6. Corrosion (engine wear)
7. Lubricity (engine wear)
8. Fuel flash point (safety)

(D) The applicant must provide information on the candidate alternative diesel fuel to determine if there are chemicals in the fuel that may increase levels of toxic compounds or potentially form toxic compounds in the fuel. The applicant will conduct an analysis for metals and elements by a method specified by the applicant. Copper, iron, cerium, lead, cadmium, chromium, and phosphorus must be included in the analysis. Additional analysis for other toxic compounds may be required after reviewing the chemical composition of the candidate alternative diesel fuel and its additives. (Note: For alternative diesel fuels that are in part comprised of standard diesel fuel, such as emulsified diesel fuels, a toxic analysis of the diesel base fuel is not necessary).

(E) With the approval of the Executive Officer or designee, an applicant may also specify different fuel parameters and test methods that are appropriate to better characterize the candidate alternative diesel fuel.

(3) Upon review of the proposed test protocol, the Executive Officer or designee may require additional fuel components, parameters, and specifications to be determined. Reference Fuel Specifications. The reference fuel used in the comparative testing described in Section 2710(d) allows the applicant three options in selecting a reference fuel.

(4)(A) Option (1). The first option is to use a 10 percent aromatic California diesel reference fuel . The reference fuel must be produced from straight-run California diesel fuel by a hydrodearomatization process and must have the characteristics set forth below under "Reference Fuel Specifications" (the listed ASTM methods are incorporated herein by reference).

(B) Option (2). The second option is to make the reference fuel from a custom blend using a "like" California diesel fuel made from a straight-run California diesel fuel by a hydroaromatization process and must have the characteristics set forth below under "Reference fuel Specifications. In addition the reference fuel must exhibit the bell shaped distillation curve characteristic of diesel fuel and no chemical feedstocks or pure chemicals such as solvents can be used as blend stocks. Details of the source and specifications of the feedstocks must be provided in the protocol and the processes and diesel feedstocks used to make the reference fuel must be reviewed and approved by the Executive Officer.

(C) Option (3). For alternative diesel fuels that contain diesel as a base fuel such as emulsified diesel fuel and 80:20 biodiesel fuel (80 percent diesel/20 percent biodiesel), the base diesel fuel used to make the alternative diesel fuel can be used in place of the 10 percent aromatic California diesel reference fuel. The base diesel fuel must be a certified, commercially available diesel fuel sold in California. The sulfur content, aromatic hydrocarbon content, polycyclic aromatic hydrocarbon content, nitrogen content, natural cetane number, API gravity, viscosity, and distillation specifications must be provided for the base diesel fuel used for the reference fuel.

Table 6. Fuel Test Methods and Reference Fuel Specifications

| Property | General Reference Fuel Specifications | ASTM Test Method |
|---|---|---|
| Sulfur Content | 500 ppm max | D5453-93 |
| Aromatic Hydrocarbon content, Vol. % | 10% max | D5186-96 |
| Polycyclic Aromatic Hydrocarbon content % | 1.4% max | D5186-96 |
| Nitrogen Content | 10 ppm max | D4629-96 |
| Natural Cetane Number | 48 min | D613-84 |
| Gravity, API | 33-39 | D287-82 |
| Viscosity at 40°, cSt | 2.0-4.1 | D445-83 |
| Flash point, °F | 130 | D93-80 |
| Distillation, °F | | D86-96 |
| IBP | 340-420 | |
| 10%REC | 400-490 | |
| 50%REC | 470-560 | |
| 90%REC | 550-610 | |
| EP | 580-660 | |

(5) The identity of the entity proposed to conduct the tests described in Section 2710(d);

(6) Reasonably adequate quality assurance and quality control procedures;

(7) Notification of any outlier identification and exclusion procedure that will be used, and
(8) A demonstration that any procedure meets generally accepted statistical principles.

(c) Application for Alternative Diesel Fuel Emission Reduction Verification. Upon completion of the tests, the applicant may submit an application for verification to the Executive Officer or designee. The application must follow the format in Section 2702(d) as applicable and include:
(1) The approved test protocol,
(2) All of the test data,
(3) Copy of the complete test log prepared in accordance with Section 2710(d)(3)(B),
(4) A demonstration that the candidate alternative diesel fuel meets the requirements for verification set forth in this section, and
(5) Such other information as the Executive Officer or designee may reasonably require.

(d) Emissions Test Procedures for Particulates, Nitrogen Oxides, Soluble Organic Fraction, Hydrocarbons, and Toxics.
(1) Criteria pollutants test requirements. In each test of a fuel, exhaust emissions of $NO_x$, $NO_2$ (pursuant to Section 2706(a)(2)), total PM, carbon monoxide, carbon dioxide, and hydrocarbons must be measured. In addition, for each test the soluble organic fraction (SOF) of the particulate matter in the exhaust emissions must be determined in accordance with the Air Resources Board's "Test Method for Soluble Organic Fraction (SOF) Extraction " dated April 1989, which is incorporated herein by reference.
(2) Toxic emissions sampling and analysis requirements. Exhaust emissions of formaldehyde, acetaldehyde, benzene, toluene, ethyl benzene, xylenes, butadiene, and polycyclic aromatic hydrocarbons are to be sampled and analyzed as specified in Table 7 for a minimum of three test samples collected from separate emission test repetitions.

Table 7. Toxics sampling and analysis [1,2]

| Toxics | Method |
|---|---|
| Formaldehyde and acetaldehyde | ARB SOP 104 |
| Benzene toluene, ethyl benzene, xylenes, and butadiene | ARB SOP 102/103 |
| Polycyclic aromatic hydrocarbons | ARB method 429[3] |

[1]Additional toxics sampling may be required depending on the chemical composition of the additives in the fuel.

[2]At a minimum tunnel blanks are required prior to and after conducting toxic emissions sampling for the reference fuel and candidate alternative diesel fuel.
[3]PAH sampling consists of a filter to collect particulate PAHs and XAD resin to collect volatile PAHs. The sampling protocol needs to be included in the test protocol. Analysis of the samples will be performed by ARB method 429.

(3) Emission test requirements and test sequence for emissions test program.

(A) The applicant must follow the emission test requirements from Section 2703 subsections (a), (b), (k), (l), (m), and (n). For all on-road, off-road, and stationary diesel vehicles and equipment, the applicant must conduct engine dynamometer testing using the Federal Test Procedure (FTP) Heavy-duty Transient Cycle, in accordance with the provisions in the Code of Federal Regulations, Title 40, Part 86, Subpart N. The applicant must use one of the following test sequences:

1. If both cold start and hot start exhaust emission tests are conducted, a minimum of five exhaust emission tests must be performed on the engine with each fuel, using either of the following sequences, where "R" is the reference fuel and "C" is the candidate alternative diesel fuel: RC CR RC CR RC (and continuing in the same order) or RC RC RC RC RC (and continuing in the same order). The engine mapping procedures and a conditioning transient cycle must be conducted with the reference fuel before each cold start procedure using the reference fuel. The reference cycle used for the candidate alternative diesel fuel must be the same as determined for the reference fuel.
2. If only hot start exhaust emission tests are conducted, one of the following test sequences must be used throughout the testing, where "R" is the reference fuel and "C" is the candidate alternative diesel fuel:

   Alternative 1: RC CR RC CR (continuing in the same order for a given calendar day; a minimum of twenty individual exhaust emission tests must be completed with each fuel)

   Alternative 2: RR CC RR CC (continuing in the same order for a given calendar day; a minimum of twenty individual exhaust emission tests must be completed with each fuel)

   Alternative 3: RRR CCC RRR CCC (continuing in the same order for a given calendar day: a minimum of twenty-one individual exhaust emission tests must be completed with each fuel)

For all alternatives, an equal number of tests must be conducted using the reference fuel and the candidate alternative diesel fuel on any given calendar day. At the beginning of each calendar day, the sequence of testing must begin with the fuel that was tested at the end of the preceding day. The engine mapping procedures and a conditioning transient cycle must be conducted at the beginning of each day for the reference fuel. The reference cycle used for the candidate alternative diesel fuel must be the same as determined for the reference fuel.

3. Alternative test sequence. The applicant may request the Executive Officer to approve an alternative test sequence in place of the above test sequences. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the following:
   (i.) Statistical and scientific equivalence to 1. or 2., and
   (ii.) Body of existing test data using the alternative test sequence.

(B) The applicant must submit a test schedule to the Executive Officer or designee at least one week prior to commencement of the tests. The test schedule must identify the days on which the tests will be conducted, and must provide for conducting test consecutively without substantial interruptions other than those resulting from the normal hours of operations at the test facility. The Executive Officer or designee should be permitted to observe any tests. The party conducting the tests must maintain a test log which identifies all tests conducted, all engine mapping procedures, all physical modifications to or operational tests of the engine, all recalibrations or other changes to the test instruments, and all interruptions between tests, and the reason for each interruption. The party conducting the tests or the applicant must notify the Executive Officer or designee by telephone and in writing of any unscheduled interruption resulting in a test delay of 48 hours or more, and the reason for such delay. Prior to restarting the test, the applicant or person conducting the tests must provide the Executive Officer or designee with a revised schedule for the remaining tests. All tests conducted in accordance with the test schedule, other than any test rejected in accordance with an outlier identification and exclusion procedure included in the approved test protocol, must be included in the comparison of emissions.

(C) Upon approval of the Executive Officer or designee, the applicant may specify an alternative test sequence to Section 2710(d)(3)(A). The applicant must provide the rationale demonstrating that the alternative test sequence better characterizes the average emissions difference between the reference fuel and the alternative diesel fuel.

(e) Durability.
   (1) The applicant must meet the durability demonstration requirements in Section 2704 subsections (a), (b), (d), (e), and (h) with the exceptions of emission testing and fuel requirements. If the applicant's diesel emission control strategy includes hardware components in addition to the alternative diesel fuel, then the emission testing requirements in Section 2704 apply.
   (2) The applicant must provide test data obtained after completion of the service accumulation, described in Section 2704(d), showing that the candidate alternative diesel fuel does not adversely affect the performance and operation of diesel engines or cause premature wear or cause damage to diesel engines. This must include but is not limited to lubricity, corrosion, and damage to engine parts such as fuel injector tips. The applicant must provide data showing under what temperature and conditions the candidate alternative diesel fuel remains stable and usable in California.

(f) Multimedia Assessment for Fuel Strategies. Diesel emission control strategies which rely on fuel changes either through use of additives or through use of alternative diesel fuels must undergo an evaluation of the multimedia effects. No diesel emission control strategy that relies on the use of an additive or an alternative fuel may be verified unless a multimedia evaluation of the additive or alternative fuel has been conducted and the California Environmental Policy Council established by Public Resources Code section 71017 has determined that such use will not cause a significant adverse impact on the public health or the environment, pursuant to Health and Safety Code section 43830.8. No person shall sell, offer for sale, supply or offer for supply an alternative fuel or a diesel fuel in California that contains an additive for use in a verified diesel emission control strategy unless such a multimedia evaluation has been conducted and resulted in a determination that use of the alternative fuel or additive will not cause a significant adverse impact on the public health and the environment. The applicant shall bear the expense of conducting the multimedia assessment.

(g) Other Requirements..
   (1) The candidate alternative diesel fuel must be in compliance with applicable federal, state, and local government requirements.
   (2) Applicants planning to market fuel in California must contact and register with the U.S. EPA and the California Dept. of Food and Agriculture. Contacts are listed below.
   Office of Transportation and Air Quality
   U.S. EPA Head Quarters
   Ariel Rios Blvd.
   1200 Pennsylvania Ave, N.W.
   Washington DC 20468
   Phone (202) 564-9303

Petroleum Products/Weighmaster Enforcement Branch
Division of Measurement Standards
Dept. of Food and Agriculture
8500 Fruitridge Road, Sacramento CA 95826
Phone (916) 229-3000

(3) Additional government agencies such as the California Energy Commission, Area Council Governments, and Local Air Quality Management Districts may be contacted to facilitate the marketing of alternative diesel fuel in California.

(h) Conditional Verification.

(1) The Executive Officer may grant a conditional verification for an alternative diesel fuel for off-road or stationary application only after the conditional verification for on-road application is granted. The Executive Officer may grant a conditional verification for on-road application if the applicant meets the following conditions:

(A) The applicant has applied for U.S. EPA registration of the alternative diesel fuel;

(B) The U.S. EPA has granted a research and development exemption or otherwise granted permission for the alternative diesel fuel to be used, and;

(C) All relevant requirements of Sections 2700-2710 have been met with the exception that registration with the U.S. EPA has not been completed.

(D) Multimedia Assessment as specified in Section 2710 (f).

(2) Where conditional verification is granted, full verification must be obtained by completing the U.S. EPA registration process within a year after receiving conditional verification. During that year, conditional verification is equivalent to verification for the purposes of satisfying the requirements of in-use emission control regulations.

(i) Extensions of an Existing Verification. See Section 2702 (g). The applicant may request the Executive Officer to approve a reduced number of emission tests when extending an existing verification to other emission control groups. In reviewing this request, the Executive Officer may consider all relevant information including, but not limited to, the following:
(1) Variability in the test results used for the existing verification,(2) Characteristics of the duty cycles in the other emission control groups,
(3) The mechanism by which the alternative diesel fuel reduces emissions, and
(4) Body of existing test data.

NOTE: Authority cited: Sections 39002, 39003, 39500, 39600, 39601, 39650-39675, 40000, 43000, 43000.5, 43011, 43013, 43018 and 43105, 43600, 43700, 43830.8

Health and Safety Code. Reference: Sections 39650-39675, 43000, 43009.5, 43013, 43018, 43101, 43104, 43105, 43106, 43107, 43204-43205.5, and 43830.8 Health and Safety Code; Section 71017 Public Resources Code, Title 17 California Code of Regulations Section 93000.

**Cal/EPA - Air Resources Board**

# Diesel Emission Control Strategies Verification Level 1 Verified Technologies

*This page updated September 29, 2005*

Level 1 verification is for those technologies achieving at least 25% or greater reduction in particulate matter. The current verified technologies are listed below. Please read the verification letter(s) below which provide additional information on the applicability of the device for your particular engine. Click on the link below each system for a list of engine families for which devices have been approved (engine series names are provided for reference in most cases). For more detailed information or to purchase the device, please contact the device manufacturer directly. New information will be posted as additional systems are verified. Please check periodically for updates.

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## Level 1 - 25 Percent or Greater Reduction in Particulate Matter:

- The ARB has verified **Lubrizol Engine Control System's** AZ Purifier and AZ Purimuffler for certain 1991 to 2003 model year, medium heavy-duty Cummins and Navistar/International diesel engines used in on-road applications operating on ultra low sulfur diesel fuel. The verification has been extended to include certain 1973-1993 model year Detroit Diesel Corporation engines used in on-road applications operating on CARB diesel as well as certain Cummins and DDC heavy heavy-duty engines model year 1991-2002, 4 stroke, used in on-road applications with ultra low sulfur diesel fuel. The AZ Purifier and AZ Purimuffler uses a diesel oxidation catalyst to achieve a 25 percent reduction in particulate matter emissions, qualifying it for a Level 1 verification. Specific engine families and conditions for which AZ Purifier and AZ Purimuffler have been approved may be found in the Executive Order which is listed below.

**AZ Purifier and AZ Purimuffler**

| | | |
|---|---|---|
| September 23, 2005 | EXECUTIVE ORDER DE-04-013-02 | Attachment |
| July 13, 2005 | EXECUTIVE ORDER DE-04-013-01 | |

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- The ARB verified the Donaldson **DCM diesel oxidation catalyst (DOC) muffler with 6000 Series catalyst formulation** alone and the **DCM DOC muffler** with the **Donaldson Spiracle™ closed crankcase filtration system** used with California diesel fuel or fuel with a lower sulfur content for model years 1988-1990. These systems will provide at least a 25 percent reduction in PM emissions. Please read the Executive Orders for conditions which these systems have been approved. Specific engine families that apply are listed in the attachment below.

**DCM DOC Muffler with 6000 Series Catalyst Formulation**

| | | |
|---|---|---|
| September 8, 2004 | EXECUTIVE ORDER DE-04-009 | Attachment |

**DCM DOC Muffler with 6000 Series Catalyst Formulation and the Donaldson Spiracle™ Closed Crankcase Filtration System**

September 8, 2004 | EXECUTIVE ORDER DE-04-010 | Attachment

- The ARB previously verified the following three systems from Donaldson Company:

(1) The **Donaldson DCM diesel oxidation catalyst (DOC) mufflers with 6000 Series catalyst formulation** plus closed loop crankcase with **Donaldson Spiracle ™ closed crankcase filtration systems** with commercially available California diesel fuel or fuel with a lower sulfur content. This system can be used in engines used in on-road applications belonging to the specified engine families in model years 1991 - 2002.

(2) The **Donaldson DCM DOC mufflers with 6100 Series catalyst formulation** plus closed loop crankcase with **Donaldson Spiracle ™ closed crankcase filtration systems** with 15 ppm or less sulfur diesel fuel. This system can be used in engines used in on-road applications belonging to the specified engine families in model years 1991 - 2002.

(3) The **Donaldson DCM DOC mufflers with 6100 Series catalyst formulation** alone on 15 ppm or less sulfur fuel. This system can be used in engines used in on-road applications belonging to the specified engine families in model years 1994 - 2002.

All of these engines are four-stroke, turbocharged, with horsepower rating of greater than 150 bhp and were certified in California to the 0.1 or 0.25 gram per brake horsepower-hour (g/bhp-hr) particulate matter (PM) emission standard when new. Click on the links below for a list of engine families for which devices have been approved (engine series names are provided for reference in most cases).

**Model Years 1991 - 1993**

- Caterpillar
- Cummins
- Detroit Diesel
- General Motors
- Mercedes Benz
- Mack
- Navistar (International)
- Volvo
- Mitsubishi
- Perkins
- Ford
- Hino
- Isuzu
- Nissan
- Renault

**Model Years 1994 - 2002**

- Caterpillar
- Cummins
- Detroit Diesel
- General Motors
- Mercedes Benz
- Navistar (International)
- Volvo
- Mack
- Hino
- Isuzu

**Read the Verification Letter:**

| | | |
|---|---|---|
| **November 7, 2002** | **Donaldson Company Verification Letter** | (PDF - 73K) |

The ARB has verified the following **Donaldson system for off-road engines** used in yard tractors, large lift trucks, top picks, side picks and gantry cranes:

**Donaldson DCM diesel oxidation catalyst mufflers with 6000 Series catalyst formulation** plus closed loop crankcase with **Donaldson Spiracle™ closed crankcase filtration system** with California diesel or lower sulfur fuel strategy. This system may be used for some four-stroke, turbocharged diesel engines ranging from 150 to 600 hp and has been verified to reduce emissions of diesel particulate matter by an average of at least 25%. Please click on the links below for a list of engine families for which the system has been approved:

- Case
- Caterpillar
- Cummins
- Detroit Diesel
- Komatsu

**Read the Verification Letter:**

| | | |
|---|---|---|
| **May 2, 2003** | **Donaldson Company Verification Letter (Off-Road)** | (PDF - 264K) |

- The ARB has verified the following Lubrizol Engine Control System's **AZ Purifier and AZ Purimuffler** for 1996 to 2002 model year off-road diesel engines. The application includes off-road equipment at ports, railway yards, and other intermodal / freight operation. The verification requires the use of ultra low sulfur diesel fuel that contains a maximum of 15 ppm sulfur. The Executive Order includes restrictions for this verification. Please click on the link below for a list of engine families for which the system has been verified.

| | | |
|---|---|---|
| **May 10, 2004** | **Lubrizol Engine Control Systems AZ Purifier™ and AZ Purimuffler™ Executive Order** | (PDF - 63K) |
| | **Lubrizol Engine Control Systems AZ Purifier™ and AZ Purimuffler™ Attachment** | (PDF - 40K) |

## Level 1 - 25 Percent or Greater PM Reduction with 25 Percent NOx Reduction:

- The ARB verified the Cleaire **Flash and Match™ oxidation catalyst based system** for use with specific 1993 through 1998 model year diesel engines in on-road applications. The system combines a diesel oxidation catalyst with engine modifications to achieve 25 percent PM reductions, and under certain conditions, a reduction in NOx of 25 percent. This verification applies only to Cummins M11

engines, for steady state applications (e.g. long haul trucks). Other restrictions which apply to these verifications may be found in the verification letters.

- Cummins (Tables Provided by Cummins, Inc.)

**Read the Verification Letters:**

| | | |
|---|---|---|
| **April 26, 2002** | **Cleaire Flash and Match™ Verification Letter** | Attachment |
| **May 14, 2003** | **Cleaire Flash and Match™ Extension Letter for 1993 Engines** | Attachment |

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- The ARB has verified the **Extengine Transport Systems Advanced Diesel Emission Control (ADEC)** system for 1991 to 1995 model year off-road Cummins 5.9-liter diesel engines from 150 to 200 horsepower, which are used in excavators, dozers, and loaders, all with rubber tires, and utility tractor rigs operating on standard CARB or ultra low sulfur diesel fuel. The ADEC system employs a diesel oxidation catalyst, selective catalytic reduction catalyst, and ammonia slip catalyst to achieve a 25 percent reduction in particulate matter emissions, qualifying it for a Level 1 verification. The system also achieves an 80 percent reduction in NOx emissions. Specific conditions for which the ADEC system has been approved may be found in the Executive Order posted below.

| | |
|---|---|
| **January 20, 2005** | Executive Order DE-05-001 |

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Diesel Risk Reduction Program

**State of California**
**AIR RESOURCES BOARD**

**EXECUTIVE ORDER DE-04-010**

Pursuant to the authority vested in the Air Resources Board (ARB) by Health and Safety Code, Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code section 39515 and 39616 and Executive Order G-02-003;

Relating to Exemptions under section 27156 of the Vehicle Code, and Verification under sections 2700 through 2710 of Title 13 of the California Code of Regulations

Donaldson Company, Inc.'s
DCM Diesel Oxidation Catalyst (DOC) Muffler with Series 6000 catalyst formulation and Spiracle™ Closed Crankcase Ventilation (CCV) Filtration System

ARB has reviewed Donaldson Company, Inc.'s request for verification of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System. Based on an evaluation of the data provided, and pursuant to the terms and conditions specified below, the Executive Officer of ARB hereby finds that the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System reduces emissions of diesel particulate matter (PM) consistent with a Level 1 device (greater than or equal to 25 percent reductions) (Title 13 California Code of Regulations ("CCR") sections 2702 (f) and (g) and section 2708). Accordingly, the Executive Officer determines that the system merits verification and, subject to the terms and conditions specified below, classifies the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System as a Level 1 system, for the applications listed in Table 1 and engine families listed in Attachment 1.

Table 1: Appropriate Applications for the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System

| Diesel Emission Control Strategy | Application |
|---|---|
| DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System | On-Road Applications only |

The aforementioned verification is subject to the following terms and conditions:

- The engines are originally manufactured from model year 1988 through 1990 having the engine family numbers listed in Attachment 1.
- The engines are between 150 and 600 horsepower.
- The engines do not employ exhaust gas recirculation.
- The application must have a duty cycle with normal exhaust temperature profiles greater than 100 degrees Celsius and below 550 degrees Celsius.
- The engine must not have a pre-existing diesel particulate filter or diesel oxidation catalyst.
- The engine must be certified in California for on-road applications.
- The engine must be certified at a PM emission level of at most 0.6 grams per brake horsepower-hour (g/bhp-hr), and greater than 0.01 g/bhp-hr.
- The engine must be four-stroke.
- The engine must be turbocharged.
- The engine can be mechanically or electronically injected
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on fuel that has a sulfur content of no more than 350 parts per million by weight.
- The other terms and conditions specified below.

IT IS ALSO ORDERED AND RESOLVED: That installation of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System, manufactured by Donaldson Company, Inc. of P.O. Box 1299, Minneapolis, Minnesota 55440-1299, has been found not to reduce the effectiveness of the applicable vehicle pollution control system, and therefore, the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System is exempt from the prohibitions in section 27156 of the Vehicle Code for installation on heavy-duty on-road vehicles listed in Attachment 1.

This exemption is only valid provided the engines meet the aforementioned conditions.

The DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System consists of a diesel oxidation catalyst and a closed crankcase ventilation filtration system. The major components of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System are identified in Attachment 2. Replacement of the Spiracle™ filter is required at every oil change (maximum of 25,000 miles) or 500 hours of operation as specified in the owner's manual.

This Executive order is valid provided that installation instructions for the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System do not recommend tuning the vehicle to specifications different from those of the vehicle manufacturer.

Changes made to the design or operating conditions of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System, as exempted by ARB, which adversely affect the performance of the vehicle's pollution control system, shall invalidate this Executive Order.

No changes are permitted to the device. The ARB must be notified in writing of any changes to any part of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System. Any changes to the system must be evaluated and approved by ARB. Failure to do so shall invalidate this Executive Order.

Marketing of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System using identification other than that shown in this Executive Order or for an application other than that listed in this Executive Order shall be prohibited unless prior approval is obtained from ARB.

This Executive Order shall not apply to any DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System advertised, offered for sale, sold with, or installed on a motor vehicle prior to or concurrent with transfer to an ultimate purchaser.

As specified in the Diesel Emission Control Strategy Verification Procedure (Title 13 CCR section 2706 (g)), the ARB assigns each Diesel Emission Control Strategy a family name. The designated family name for the verification as outlined above is: CA/DON/2004/PM1/N00/ON/SYS04.

Additionally, as stated in the Diesel Emission Control Strategy Verification Procedure, Donaldson Company, Inc. is responsible for honoring their warranty (section 2707) and conducting in-use compliance testing (section 2709).

In addition to the foregoing, ARB reserves the right in the future to review this Executive Order and the exemption and verification provided herein to assure that the exempted and verified add-on or modified part continues to meet the standards and procedures of California Code of Regulations, Title 13, section 2222, et seq and California Code of Regulations, Title 13, sections 2700 through 2710.

Systems verified under this Executive Order shall conform to all applicable California emissions regulations.

Violation of any of the above conditions shall be grounds for revocation of this Executive Order.

Executed at El Monte, California, this 8th day of September 2004.

//s//

Robert H. Cross, Chief
Mobile Source Control Division

Attachment 1: ARB Approved Model Year 1988 to 1990 Engine Families for the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System

Attachment 2: Part Numbers and Model Numbers of the DCM DOC Muffler with Series 6000 catalyst formulation and Spiracle™ CCV Filtration System

Winston H. Hickox
*Agency Secretary*

# Air Resources Board

**Alan C. Lloyd, Ph.D.**
**Chairman**
9528 Telstar Avenue • P.O. Box 8001 • El Monte, California 91731 • www.arb.ca.gov

Gray Davis
*Governor*

November 7, 2002

Reference No. RAS-02-33

Mr. Julian Imes
Director, Exhaust/Emissions Technology
Donaldson Company, Inc.
P.O. Box 1299
Minneapolis, MN 55440-1299

Dear Mr. Julian Imes:

The California Air Resources Board (ARB) has reviewed your request for verification using the Verification Procedure for In-Use Strategies to Control Emissions from Diesel Engines in Appendix A of the Staff Report for the following systems:

(1) The Donaldson DCM diesel oxidation catalyst (DOC) mufflers with 6000 Series catalyst formulation plus closed loop crankcase with Donaldson Spiracle ™ closed crankcase filtration systems with commercially available California diesel fuel or fuel with a lower sulfur content. Based on its evaluation of the data provided, ARB hereby verifies that this system reduces emissions of diesel particulate matter (PM) consistent with a Level 1 system in engines used in on-road applications belonging to the engine families listed in Table 1 in Attachment A and Table 2 in Attachment B.

As specified in the Diesel Emission Control Strategy Verification Procedure, the ARB assigns each Diesel Emission Control Strategy a family name. The designated family name for this system is **CA/DON/2002/PM1/N00/ON/SYS01.** This identification number should be used in reference to this verification as part of the system-labeling requirement.

(2) The Donaldson DCM DOC mufflers with 6100 Series catalyst formulation plus closed loop crankcase with Donaldson Spiracle ™ closed crankcase filtration systems with 15 ppm or less sulfur diesel fuel. Based on its evaluation of the data provided, ARB hereby verifies that this system reduces emissions of diesel PM consistent with a Level 1 system in engines used in on-road applications belonging to the engine families listed in Table 1 in Attachment A and Table 2 in Attachment B.

The designated family name for this system is **CA/DON/2002/PM1/N00/ON/SYS02.** This identification number should be used in reference to this verification as part of the system-labeling requirement.

(3) The Donaldson DCM DOC mufflers with 6100 Series catalyst formulation alone on 15 ppm or less sulfur fuel. Based on its evaluation of the data provided, ARB hereby verifies that this system reduces emissions of diesel PM consistent with a Level 1 system in engines used in on-road applications belonging to the engine families listed in Table 2 located in Attachment B.

The designated family name for this system is **CA/DON/2002/PM1/N00/ON/SYS03.** This identification number should be used in reference to this verification as part of the system-labeling requirement.

To meet the conditions of this verification, the Spiracle CCV Filtration System requires that the filter cartridge must be changed at every lube oil change recommended by the engine manufacturer or every 500 hours, whichever comes first.

The aforementioned verifications are valid provided that the engine is both certified in California for on-road applications and used in on-road applications.

The ARB estimates that these systems will incur no discernible fuel economy penalty when used in a compatible application.

Additionally, as stated in the Diesel Emission Control Strategy Verification Procedure, Donaldson Company, Inc. is responsible for honoring a warranty (Section 2707) and conducting in-use compliance testing (Section 2709).

Thank you for participating in ARB's diesel emission control strategy verification program. Should you have any questions or comments, please contact Ms. Annette Hebert, Branch Chief, Heavy-Duty Diesel In-Use Strategies Branch, at (626) 575-6973.

Sincerely,

/s/

Robert H. Cross, Chief
Mobile Source Control Division

Attachments

**State of California**
**AIR RESOURCES BOARD**

**EXECUTIVE ORDER DE-04-013-02**

Pursuant to the authority vested in the Air Resources Board by Health and Safety Code, Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code section 39515 and 39616 and Executive Order G-02-003;

Relating to Verification under Sections 2700 through 2710 of Title 13 of the California Code of Regulations

Lubrizol Engine Control Systems
AZ Purifier™ and AZ Purimuffler™

The California Air Resources Board (ARB) has reviewed Lubrizol Engine Control System's request for verification of the AZ Purifier™ and AZ Purimuffler™. Based on an evaluation of the data provided, and pursuant to the terms and conditions specified below, the Executive Officer of the ARB hereby finds that the AZ Purifier™ and AZ Purimuffler™ reduce emissions of diesel particulate matter (PM) consistent with a Level 1 system (greater than or equal to 25 percent reductions) (Title 13 California Code of Regulations (CCR) Sections 2702 (f) and (g) and Section 2708). Accordingly, the Executive Officer determines that the system merits verification and, subject to the terms and conditions specified below, classifies the AZ Purifier™ and AZ Purimuffler™ as a Level 1 system, for the application listed in Table 1 and engine families listed in Attachment 1.

Table 1: Appropriate Applications for the AZ Purifier™ and AZ Purimuffler™

| Diesel Emission Control Strategy | Application |
|---|---|
| AZ Purifier™ and AZ Purimuffler™ | On-road Application |

The aforementioned verification is subject to the following terms and conditions:
**For Cummins and Navistar Engines:**
- The engines are on-road medium heavy-duty diesel engines (model year 1991 to 2003) listed in Attachment 1, Table 1.
- The engine is four-stroke.
- The engine does not include an exhaust gas recirculation system.
- The engine can be turbocharged or naturally aspirated.
- The engine must not have a pre-existing oxidation catalyst.

- The engine must not have a pre-existing diesel particulate filter.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on diesel fuel (e.g. not biodiesel blends or alternative diesel fuels) with a sulfur content of no more than 15 parts per million by weight.
- The product must not be operated with fuel additives, as defined in Section 2701 of Title 13, of the California Code of Regulations, unless explicitly verified for use with the fuel additive(s).
- The product must not be used with any other systems or engine modifications without ARB and manufacturer approval.
- The other terms and conditions specified below.

**For Detroit Diesel Corporation Engines:**

- The engines are originally manufactured from model years 1973 through 1993 listed in Attachment 1, Tables 2 and 3.
- The engine may be manufactured before the adoption of on-road certification regulations in California.
- Engines manufactured before 1988 must be equipped with a backpressure monitor.
- Engines manufactured from 1988 - 1990 must be certified at a PM emission level of at most 0.6 grams per brake horsepower-hour (g/bhp-hr) and greater than 0.01 g/bhp-hr.
- Engines manufactured from 1991 - 1993 must be certified at a PM emission level of at most 0.25 g/bhp-hr and greater than 0.01 g/bhp-hr.
- The engine is two-stroke.
- The engine can be turbocharged or naturally aspirated.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on diesel fuel (e.g. not biodiesel, biodiesel blends or alternative diesel fuels) with a sulfur content of no more than 350 parts per million by weight.
- The engine must not have a pre-existing oxidation catalyst.
- The engine must not have a pre-existing diesel particulate filter.
- The product must not be operated with fuel additives, as defined in Section 2701 of Title 13, of the CCR, unless explicitly verified for use with the fuel additive(s).
- The product must not be used with any other systems or engine modifications without ARB and manufacturer approval.
- The other terms and conditions specified below.

**For Cummins and Detroit Diesel Corporation Engines:**

- The engines are on-road heavy heavy-duty diesel engines (model year 1991 to 2002) listed in Attachment 1, Table 1-1.
- The engine is four-stroke.
- The engine does not include an exhaust gas recirculation system.
- The engine can be turbocharged or naturally aspirated.
- The engine must not have a pre-existing oxidation catalyst.
- The engine must not have a pre-existing diesel particulate filter.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on diesel fuel (e.g. not biodiesel blends or alternative diesel fuels) with a sulfur content of no more than 15 parts per million by weight.
- The product must not be operated with fuel additives, as defined in Section 2701 of Title 13, of the CCR, unless explicitly verified for use with the fuel additive(s).
- The product must not be used with any other systems or engine modifications without ARB and manufacturer approval.
- The other terms and conditions specified below.

IT IS ALSO ORDERED AND RESOLVED: That installation of the AZ Purifier™ and AZ Purimuffler™, manufactured by Lubrizol Engine Control Systems of 165 Pony Drive, Newmarket, Ontario, Canada L3Y 7V1, has been found not to reduce the effectiveness of the applicable vehicle pollution control system, and therefore, the AZ Purifier™ and AZ Purimuffler™ is exempt from the prohibitions in Section 27156 of the Vehicle Code for installation on on-road vehicles with engines listed in Attachment 1, Tables 1 - 3.

This exemption is only valid provided the engines meet the aforementioned conditions.

The AZ Purifier™ is a catalyst module that is typically installed in the engine exhaust piping upstream of the original vehicle muffler. The AZ Purimuffler™ is an integrated converter muffler, which is installed in place of the original vehicle muffler and is normally purchased as direct fit designs. The major components of the AZ Purifier™ and AZ Purimuffler™ are identified in Attachment 2, Tables 1 and 2.

This Executive Order is valid provided that installation instructions for the AZ Purifier™ and AZ Purimuffler™ do not recommend tuning the engines to specifications different from the engine manufacturers'.

Changes made to the design or operating conditions of the AZ Purifier™ and AZ Purimuffler™, as verified by the ARB, which adversely affect the performance of the engines, shall invalidate this Executive Order.

No changes are permitted to the device. The ARB must be notified in writing of any changes to any part of the AZ Purifier™ and AZ Purimuffler™. Any changes to the device must be evaluated and approved by the ARB. Failure to do so shall invalidate this Executive Order.

Marketing of the AZ Purifier™ and AZ Purimuffler™ using identification other than that shown in this Executive Order or for an application other than that listed in this Executive Order shall be prohibited unless prior approval is obtained from the ARB.

This Executive Order shall not apply to any AZ Purifier™ and AZ Purimuffler™ advertised, offered for sale, sold with, or installed on an on-road vehicle prior to or concurrent with transfer to an ultimate purchaser.

As specified in the Diesel Emission Control Strategy Verification Procedure (Title 13 CCR Section 2706 (i)), the ARB assigns each Diesel Emission Control Strategy a family name. The designated family name for the verification as outlined above is: **CA/LUB/2004/PM1/N00/ON/DOC01**.

Additionally, as stated in the Diesel Emission Control Strategy Verification Procedure, Lubrizol Engine Control Systems is responsible for honoring their warranty (Section 2707) and conducting in-use compliance testing (Section 2709).

In addition to the foregoing, the ARB reserves the right in the future to review this Executive Order and the exemption and verification provided herein to assure that the exempted and verified add-on or modified part continues to meet the standards and procedures of CCR, Title 13, Section 2222, et seq and CCR, Title 13, Sections 2700 through 2710.

Systems certified under this Executive Order shall conform to all applicable California emissions regulations.

This Executive Order does not release Lubrizol Engine Control Systems from complying with all other applicable regulations.

Violation of any of the above conditions shall be grounds for revocation of this Executive Order.

Executed at El Monte, California, this 23rd day of September 2005.

//s//

Robert H. Cross, Chief
Mobile Source Control Division

Attachment 1: ARB Approved Engine Families for the AZ Purifier™ and AZ Purimuffler™

Attachment 2: Part Numbers and Model Numbers for the Approved AZ Purifier™ and AZ Purimuffler™

**State of California**
**AIR RESOURCES BOARD**

## EXECUTIVE ORDER DE-04-013-01

Pursuant to the authority vested in the Air Resources Board by Health and Safety Code, Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code section 39515 and 39616 and Executive Order G-02-003;

Relating to Verification under Sections 2700 through 2710 of Title 13 of the California Code of Regulations

Lubrizol Engine Control Systems
AZ Purifier™ and AZ Purimuffler™

The California Air Resources Board (ARB) has reviewed Lubrizol Engine Control System's request for verification of the AZ Purifier™ and AZ Purimuffler™. Based on an evaluation of the data provided, and pursuant to the terms and conditions specified below, the Executive Officer of the ARB hereby finds that the AZ Purifier™ and AZ Purimuffler™ reduce emissions of diesel particulate matter (PM) consistent with a Level 1 system (greater than or equal to 25 percent reductions) (Title 13 California Code of Regulations (CCR) Sections 2702 (f) and (g) and Section 2708). Accordingly, the Executive Officer determines that the system merits verification and, subject to the terms and conditions specified below, classifies the AZ Purifier™ and AZ Purimuffler™ as a Level 1 system, for the application listed in Table 1 and engine families listed in Attachment 1.

Table 1: Appropriate Applications for the AZ Purifier™ and AZ Purimuffler™

| Diesel Emission Control Strategy | Application |
|---|---|
| AZ Purifier™ and AZ Purimuffler™ | On-road Application |

The aforementioned verification is subject to the following terms and conditions:
**For Cummins and Navistar Engines:**

- The engines are on-road medium heavy-duty diesel engines (model year 1991 to 2003) listed in Attachment 1, Table 1.
- The engine is four-stroke.
- The engine does not include an exhaust gas recirculation system.
- The engine can be turbocharged or naturally aspirated.

- The engine must not have a pre-existing oxidation catalyst.
- The engine must not have a pre-existing diesel particulate filter.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on diesel fuel (e.g. not biodiesel blends or alternative diesel fuels) with a sulfur content of no more than 15 parts per million by weight.
- The product must not be operated with fuel additives, as defined in Section 2701 of Title 13, of the California Code of Regulations, unless explicitly verified for use with the fuel additive(s).
- The product must not be used with any other systems or engine modifications without ARB and manufacturer approval.
- The other terms and conditions specified below.

**For Detroit Diesel Corporation Engines:**

- The engines are originally manufactured from model years 1973 through 1993 listed in Attachment 1, Tables 2 and 3.
- The engine may be manufactured before the adoption of on-road certification regulations in California.
- Engines manufactured before 1988 must be equipped with a backpressure monitor.
- Engines manufactured from 1988 - 1990 must be certified at a PM emission level of at most 0.6 g/bhp-hr and greater than 0.01 g/bhp-hr.
- Engines manufactured from 1991 - 1993 must be certified at a PM emission level of at most 0.25 g/bhp-hr and greater than 0.01 g/bhp-hr.
- The engine is two-stroke.
- The engine can be turbocharged or naturally aspirated.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on diesel fuel (e.g. not biodiesel, biodiesel blends or alternative diesel fuels) with a sulfur content of no more than 350 parts per million by weight.
- The engine must not have a pre-existing oxidation catalyst.
- The engine must not have a pre-existing diesel particulate filter.
- The product must not be operated with fuel additives, as defined in Section 2701 of Title 13, of the California Code of Regulations, unless explicitly verified for use with the fuel additive(s).
- The product must not be used with any other systems or engine modifications without ARB and manufacturer approval.
- The other terms and conditions specified below.

IT IS ALSO ORDERED AND RESOLVED: That installation of the AZ Purifier™ and AZ Purimuffler™, manufactured by Lubrizol Engine Control Systems of 165 Pony Drive, Newmarket, Ontario, Canada L3Y 7V1, has been found not to reduce the effectiveness of the applicable vehicle pollution control system, and therefore, the AZ Purifier™ and AZ Purimuffler™ is exempt from the prohibitions in Section 27156 of the Vehicle Code for installation on on-road vehicles with engines listed in Attachment 1, Tables 1 - 3.

This exemption is only valid provided the engines meet the aforementioned conditions.

The AZ Purifier™ is a catalyst module that is typically installed in the engine exhaust piping upstream of the original vehicle muffler. The AZ Purimuffler™ is an integrated converter muffler, which is installed in place of the original vehicle muffler and is normally purchased as direct fit designs. The major components of the AZ Purifier™ and AZ Purimuffler™ are identified in Attachment 2, Tables 1 and 2.

This Executive Order is valid provided that installation instructions for the AZ Purifier™ and AZ Purimuffler™ do not recommend tuning the engines to specifications different from the engine manufacturers'.

Changes made to the design or operating conditions of the AZ Purifier™ and AZ Purimuffler™, as verified by the ARB, which adversely affect the performance of the engines, shall invalidate this Executive Order.

No changes are permitted to the device. The ARB must be notified in writing of any changes to any part of the AZ Purifier™ and AZ Purimuffler™. Any changes to the device must be evaluated and approved by the ARB. Failure to do so shall invalidate this Executive Order.

Marketing of the AZ Purifier™ and AZ Purimuffler™ using identification other than that shown in this Executive Order or for an application other than that listed in this Executive Order shall be prohibited unless prior approval is obtained from the ARB.

This Executive Order shall not apply to any AZ Purifier™ and AZ Purimuffler™ advertised, offered for sale, sold with, or installed on an on-road vehicle prior to or concurrent with transfer to an ultimate purchaser.

As specified in the Diesel Emission Control Strategy Verification Procedure (Title 13 CCR Section 2706 (i)), the ARB assigns each Diesel Emission Control Strategy a family name. The designated family name for the verification as outlined above is: **CA/LUB/2004/PM1/N00/ON/DOC01**.

Additionally, as stated in the Diesel Emission Control Strategy Verification Procedure, Lubrizol Engine Control Systems is responsible for honoring their warranty (Section 2707) and conducting in-use compliance testing (Section 2709).

In addition to the foregoing, the ARB reserves the right in the future to review this Executive Order and the exemption and verification provided herein to assure that the exempted and verified add-on or modified part continues to meet the standards and procedures of California Code of Regulations, Title 13, Section 2222, et seq and California Code of Regulations, Title 13, Sections 2700 through 2710.
Systems certified under this Executive Order shall conform to all applicable California emissions regulations.

Violation of any of the above conditions shall be grounds for revocation of this Executive Order.

Executed at El Monte, California, this _13th____ day of July 2005.

/s/
Robert H. Cross, Chief
Mobile Source Control Division

Attachment 1: ARB Approved Engine Families for the AZ Purifier™ and AZ Purimuffler™

Attachment 2: Part Numbers and Model Numbers for the Approved AZ Purifier™ and AZ Purimuffler™

# A ***Safer*** Ride to School:

## How to Clean Up School Buses and Protect Our Children s Health

*The Results of a Citizen Monitoring Study of Diesel School Buses in Atlanta, Georgia*

*January 2005*

**Southern Alliance for Clean Energy**


*Written by*

**Anne R. Gilliam**

**Ulla-Britt Reeves**

# Table of Contents

# Executive Summary

First developed in 1898, diesel engines are known for their durability, reliability and fuel economy. Yet, as modern health science has evolved over the years, we have come to understand that these engines emit large quantities of dangerous pollutants that threaten public health and our environment. Diesel exhaust contributes to elevated ambient outdoor concentrations of particulate matter and ground-level ozone, and to global warming. In December 2003, Southern Alliance for Clean Energy and the Clean Air Task Force, in partnership with Kids Against Pollution, conducted a citizen monitoring study to measure hazardous diesel particulate matter exhaust levels on school buses—specifically, how school bus self-pollution affects the air quality inside the buses that carry our children on their daily ride to and from school. This project was part of a three-city study conducted by the Clean Air Task Force and partners in Chicago, Atlanta, and Ann Arbor, MI[1]. This report summarizes the results of that study, discusses its health implications and provides recommendations for policy changes and voluntary actions that will improve the quality of the air that our children breathe on and around school buses.

The results of our study of local school buses in Atlanta, Georgia show that by retrofitting the yellow buses that children ride every day with existing pollution control technologies and clean fuels, school districts can dramatically improve cabin air quality and address this previously hidden health risk. Through our study we observed that a diesel particulate filter (DPF), used in tandem with ultra-low sulfur diesel fuel (ULSD), on a local school bus effectively eliminates all detectable particulate matter in the school bus cabin emitted from the tailpipe. We conclude that more widespread use of these technologies, in concert with other

clean air programs, could significantly reduce controllable dirty pollution from school buses and provide our children a healthier ride to and from school.

In DeKalb, Fulton, Cobb, and Gwinnett counties alone, school buses travel more than 300,000 miles a day while transporting over 284,000 kids to and from school[2,3]. Because children breathe in more air per pound of body weight than adults do, they are more susceptible to the impacts of dirty air[4]. Our public representatives and school officials should work together to reduce the health risk that school buses pose to our children. We need a strategic, multi-level plan to address the air quality on school buses. That strategy should draw upon public education, local outreach, voluntary action, financial incentives, and focused regulation.

Specifically, we recommend that school officials:

- Develop and enforce local and state anti-idling policies and laws for school buses;
- Retrofit all existing diesel buses with two specific pollution control technologies—diesel particulate filters and engine crankcase filtration systems;
- Switch buses to ultra-low sulfur diesel (ULSD) fuel;
- Create inspection and maintenance programs that keep all buses clean and performing properly; and
- Replace or rebuild all engines after they have been on the road for a decade

*Diesel pollution is a serious public health risk.* Burning diesel fuel releases a toxic cocktail of chemicals. Children breathe these chemicals when riding the bus and when standing near idling buses. Right now, we have all the tools we need to take decisive steps to reduce the health risk to children throughout metropolitan Atlanta, and across the Southeast. This report tells how.

# Introduction

The conventional yellow school bus has been around for more than 50 years—indeed, it is a cultural icon and a symbol of sound public education. And though most of the safety standards that apply to school buses have improved significantly during this period, there is one threat to children's health, a hidden threat, that has not yet been adequately addressed in our communities—air pollution inside the yellow school bus. Every day, more than one million children board Georgia's 13,410 school buses and travel to school[5]. Nationally, students spend an average of one hour a day riding the bus[6]. What parents and many school officials do not know is that the ride to school may jeopardize a student's future. Diesel pollution may compromise our children's health and interfere with their learning potential.

Numerous U.S. studies on the health impacts of air pollution conclude that exposure to air pollutants like those emitted by diesel school buses can cause short-and long-term respiratory and cardiovascular problems[7,8]. Study results suggest that the particulate matter in diesel exhaust can trigger asthma attacks; irritate the eyes, nose, throat, and bronchial system; and cause neurophysiological and respiratory symptoms, such as nausea, lightheadness, and coughing[9]. Children typically spend more time outdoors and breathe in more air per pound of body weight than adults[10]. As a result, exposure to particulate matter and other chemicals in diesel exhaust can have a more dramatic impact on children's developing body systems.

School buses are generally far and away considered the safest means of transportation for children to get to and from school in terms of accident rates. In fact, in 2003, only six children died as occupants of school buses nationally; in contrast, more than 800 children are killed on average every year making the trip to school in some other way—by car, on foot, or by bicycle[11]. Yet the fact that diesel pollution is currently unregulated counteracts some of the safety benefits of riding on the bus instead of a car. Air pollution inside the cabin of a typical school bus poses a health risk that deserves immediate public attention. With relatively simple and cost-effective solutions available, we can make a difference in the future of our children today.

In 2001, the U.S. Environmental Protection Agency (EPA) adopted the 2007 Heavy-Duty Highway Diesel Rule. The rule tightens emission standards starting in the 2007 model year for all on-road or highway diesel engines, including those in school buses, and requires a limit of 15 parts per million (ppm) of sulfur in diesel fuel. The rule will be phased in over three years. By 2010, all new buses must meet the new standards. EPA officials estimate that, by 2030, the new rule will prevent 8,300 premature deaths, 9,500 hospital visits, 1.5 million lost workdays, and 360,000 asthma attacks[12,13]. Although these numbers are significant, they fall far short of removing some of the most egregious diesel pollution sources on our roads—those engines built before 2007. These older engines are indisputably a significant human health threat because they are the least efficient and most polluting vehicles. Due to their longevity, durability and inexpensive operating costs for owners, many of these existing on-

road engines will remain in service for 30 years or more and continue to emit harmful pollutants throughout their lifespan.

Yet the technology exists today to address this problem of outdated, polluting engines. Devices are already on the market that can dramatically reduce emissions from diesel engines. Some technologies available can cut particulate matter by 90%[14]. Despite these readily available pollution controls, our school bus fleets by and large remain outdated. Unfortunately, black smoke spewing out of bus tailpipes is often still a characteristic of many school buses across the nation. In 2002, 36.1% of Georgia's school bus fleet was built before 1990[15]. A few school districts are giving priority to the purchase of new buses and the phase-in of cleaner engines, but most are not.

***Children typically spend more time outdoors and breathe in more air per pound of body weight than adults. This makes their developing body systems more susceptible to the harmful effects of diesel exhaust.***

# Health Realities

Diesel engines, both on-road (trucks, buses) and non-road vehicles (construction equipment, boats, barges, generators, trains), emit significant quantities of particulate matter and smog-forming nitrogen oxides (or ozone). This exhaust also contains carbon dioxide, carbon monoxide, black carbon, over 40 chemicals or "hazardous air pollutants" (HAPs) and toxic gases and metals, such as formaldehyde, polycyclic aromatic hydrocarbons, and acrolein[16]. Fourteen of these HAPs are known to cause cancer.

Particulate matter (PM), found in diesel exhaust, is a complex mixture of liquid and solid droplets suspended in the air. PM is emitted from various stationary and mobile sources, including diesel engines. These particles vary in chemical composition and size, from coarse particles, 10 microns in diameter and less (PM10), to fine particles less than 2.5 microns in diameter ($PM_{2.5}$), to ultrafine particles, particles less than 0.1 microns. Fine particles, less than

one-thirtieth the width of a human hair, and ultrafine particles pose the most significant threat to human health due to their small size.

Diesel exhaust is associated with many adverse health impacts and places everyone at risk when breathing dirty air. The health impacts are greatest for children, the elderly, people who have respiratory problems or who smoke, people who work or live near diesel exhaust sources and people who regularly engage in strenuous exercise in diesel-polluted areas. Pollution from diesel engines is often concentrated in urban cities and near roadways, putting millions of people at risk everyday.

Ultrafine and fine particles found in diesel exhaust penetrate deep into the lungs and can cause many adverse health impacts including respiratory and cardiopulmonary disease, lung cancer and asthma attacks. Excessive exposure to these particles over time has even been

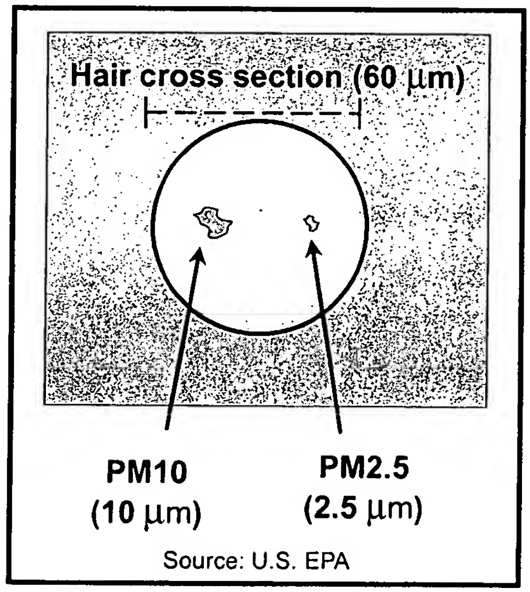
shown to lead to premature death. Over the past two decades, numerous epidemiological studies—studies of large population groups—have confirmed these conclusions[21]. In 2003, EPA responded to health reports and added fine particles to its Air Quality Index, which sets a maximum limit on fine particles.

Ultrafine particles make up a large portion of the mass of particles in diesel exhaust. These particles—0.005 to 0.05 microns in size—are comparable in size to some viruses and bacteria and are an even greater concern because they can bypass upper respiratory defenses and enter the bloodstream[22]. Ultrafine and fine particles carry toxic compounds, such as benzene and hydrocarbons, on their surfaces and can penetrate deep into the respiratory tract[23]. These particles can induce inflammatory responses in the airways and in the bloodstream[24].

***Ultrafine and fine particles penetrate deep into the lungs causing heart attacks, premature death and cancer.***

Asthma is one of the most prevalent diseases in American children and is one of the leading causes of school absenteeism. Nationally, students miss more than 14 million school days a year due to asthma-related illness[25]. In Georgia, some 210,000 children under the age of 18 have asthma, and 88,000 children with asthma missed school because of this condition[26]. While many stimuli can trigger an asthma attack, a 2002 study of California school children provides the first evidence of a suspected link between pollution and the onset of asthma. Researchers found that among 3,500 students who played outdoor sports in high ozone areas, 265 new cases of asthma were diagnosed in the five years following exposure[27].

In a 2004 statement by the American Heart Association, researchers describe evidence that short-term exposure to high levels of particulate matter significantly contributes to acute cardiovascular mortality, particularly among at-risk populations. They also found that high levels of particles in the ambient air increase hospital admissions for cardiovascular and pulmonary disease[28]. A recent study using data from the American Cancer Society indicates that people living in areas with higher than average particulate matter concentrations (an increase of just 10 micrograms of fine particles per cubic meter of air (10µg/m3) over normal concentrations) have an 8% increase in lung cancer mortality risk[29]. According to a 2001 report, exposure to particulate matter for just two hours can increase the risk of heart attacks[30].

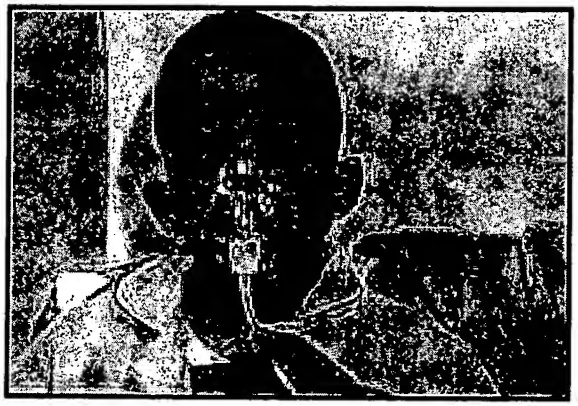



**Fine particles are less than 2.5 microns in diameter ($PM_{2.5}$), and less than one-thirtieth the width of a human hair.** (Source: U.S. EPA)

EPA concludes in their 2002 *Health Assessment Document for Diesel Engine Exhaust* that workers in occupational settings where diesel engines are present are at substantially greater risk of lung cancer than those without comparative exposure[31]. Furthermore, the review of numerous epidemiological studies by the American Heart Association concludes and there is a direct link between fine particles and health impacts with no discernable lower threshold—suggesting that there is no safe level of exposure to fine particles. In addition, the report concludes that short-term exposure to particulate matter significantly contributes to an

increase in cardiovascular mortality[32].

The health risk posed by air pollution varies by exposure duration, concentration, and individual vulnerability, among other factors. In Atlanta, children are potentially exposed to relatively high levels of particulates—both from the ambient outdoor air and from their ride on the school bus. In the U.S., children spend 3 billion hours each year on school buses[33a]. For each child, this averages out to an hour a day or 180 hours each school year sitting on the bus. As our study demonstrates, the air inside the bus can often be a lot dirtier than the polluted outdoor air many Georgians breathe on a daily basis.



Since 2001, there have been several comprehensive studies conducted on school bus emissions. In a 2002 study by Environment & Human Health Inc. (EHHI) in Connecticut, *Children's Exposure to Diesel Exhaust on School Buses*, they found that children were exposed to airborne particulate matter concentrations in tested conventional buses that were 5-15 times higher than ambient $PM_{2.5}$ levels[33b]. The Natural Resource Defense Council (NRDC) study, *No Breathing in the Aisles: Diesel Exhaust Inside School Buses*, found that $PM_{2.5}$ levels measured in a 1986 school bus exposed children to an additional 14 µg/m3 on average (the annual federal standard is 15µg/m3), above the outdoor levels they are exposed to while walking or riding in a car on the same streets[34].

Particulate matter found in diesel exhaust is also a major component of haze pollution, which restricts and impairs regional visibility. Diesel pollution also deposits on buildings and statues, leaving a thick residue that can cause permanent damage and decay. Furthermore, acidic nitrate pollution from tailpipes and other sources disrupts the natural aquatic ecosystems by leaching into the soil and contributing to excessive levels of nitrogen and other chemicals in our waterways.

Carbon dioxide ($CO_2$) and black carbon from diesel exhaust are also significant contributors to the global warming phenomenon (or climate change). Approximately ninety-four percent of diesel exhaust is made up of organic and elemental carbon[17]. Across the U.S., diesel emissions are responsible for 50 percent of man-made "black carbon soot" emissions[18]. According to a recent NASA study, soot is twice as potent as carbon dioxide in changing global surface air temperatures in the Northern Hemisphere and the Arctic[19].

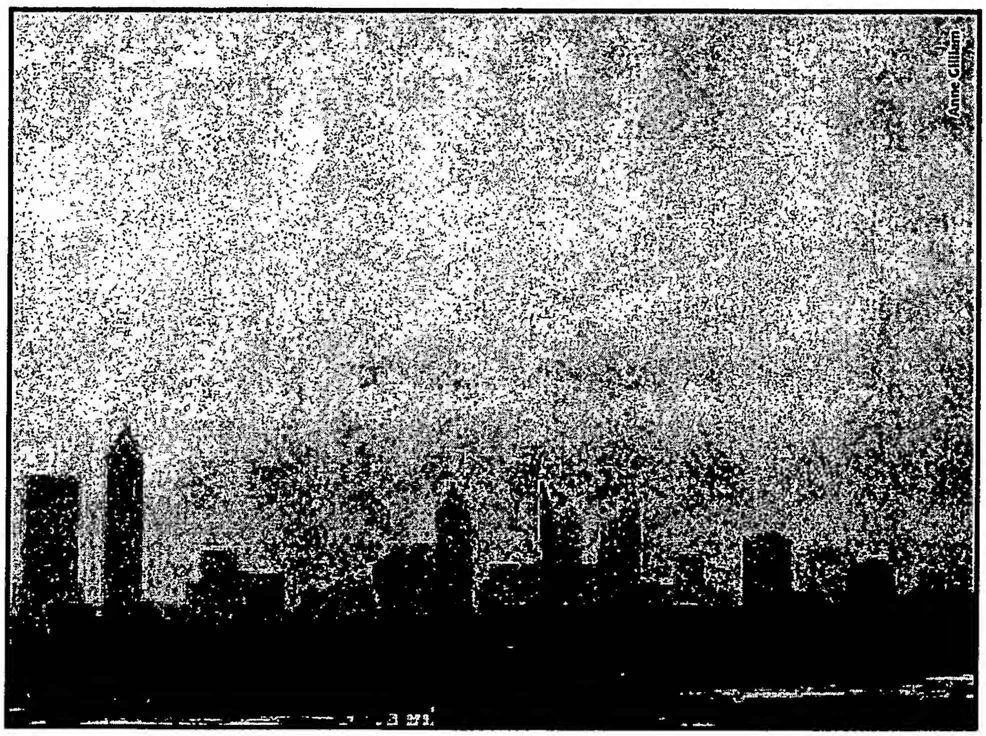
**_According to a recent NASA study, diesel black carbon soot is twice as potent as carbon dioxide in contributing to global warming._**

Unlike carbon dioxide, soot stays in the atmosphere for a much shorter time, which could mean that cleaning up black carbon in the near term would reduce global warming pollution much sooner (in weeks, as opposed to decades). When soot deposits on naturally reflective bodies of snow and ice, they become speckled with dark-colored, heat and light-absorbing particles that hinder the ability of snow and ice to effectively reflect sunlight back into the atmosphere. According to several distinguished climate researchers, this effect throws off the natural balance of heat reflection to the atmosphere and accelerates the melting of frozen areas like ice caps. As a result of these human-induced global climate imbalances, sea levels are rising and global temperatures are increasing[20].

# Nonattainment Consequences

In April 2004, the U.S. Environmental Protection Agency (EPA) designated 20 counties in the metro Atlanta area as nonattainment with the federal health standard for ground-level ozone. In addition, 33 counties in Georgia and another partial county were preliminarily designated in June 2004 as exceeding federal health standards for fine particles ($PM_{2.5}$). The 24-hour standard for $PM_{2.5}$ is 65 µg/m3 (micrograms of fine particles per cubic meter of air) and the annual average standard is 15 µg/m3. These standards were first established by EPA in 1997 and have undergone continuous re-evaluation over the years as new science shows the need for an even stricter set of standards[35]. Final designations of $PM_{2.5}$ nonattainment areas will be made by December 2004, based on air monitoring data accumulated over the past three years.

Georgians face serious consequences both environmentally and economically for these violations that will affect transportation projects and public health costs. Nonattainment areas face sanctions for federal programs and facilities, such as reductions in highway funding and construction restrictions. Construction restrictions apply to major sources, such as power plants, that are potentially large contributors to specific pollutants (i.e., ozone or particulate matter). These restrictions can create significant operational and economic burdens to the region by discouraging new growth and investment.


Atlanta Skyline 2004.

Public health costs are also likely to increase due to the increases in doctor and hospital visits in areas experiencing high levels of outdoor pollution. As the number of workdays missed and hospitalizations go up from health problems associated with respiratory ailments, productivity will decline, increasing costs to businesses and thereby impacting economic vitality. According to a recent report by the Union of Concerned Scientists (UCS), cutting pollution from today's existing diesel engines in California would result in a cumulative savings of $48 to $70 billion between 2004 and 2020 from the avoided health costs of premature death, lung cancer and hospitalizations for severe respiratory problems. Health benefits from reductions in pollution are potentially much larger as the UCS estimate does not include the potential non-quantifiable health and welfare impacts, such as minor respiratory problems, increasing asthma rates, damage to agricultural crops and forest habitats, lost workdays, and asthma attacks associated with diesel emissions[36].

Most importantly, nonattainment regions are affected by the stigma and economic losses of unhealthy air. When cities and counties are designated as nonattainment, the areas are required to implement programs to control potential increases in air pollution, which often entails cities placing restrictions on new transportation and development projects. The Atlanta metro area will undoubtedly be forced to instate similar strict requirements due to the severity of our air pollution problems. Our costs of doing business in the state and the metro Atlanta area will likely increase and could deter new businesses from locating to the area and even encourage existing businesses to relocate elsewhere in some situations. To avoid such economic losses to our cities, it is in the state's best interest to attain air quality standards as soon as possible and maintain a sustainable balance between growth and pollution control.

***In light of recent new findings linking air pollution with public health and non-attainment consequences, it is imperative that our communities address this avoidable, preventable and significant public health risk—diesel exhaust.***

# A Close-up of Citizen Air Quality Monitoring in Dekalb County, GA—Methods

In December 2003, Southern Alliance for Clean Energy (SACE) and the Clean Air Task Force (CATF)—in partnership with the DeKalb County School System; Kids Against Pollution (KAP), an Atlanta-based nonprofit advocacy group; and Dr. P. Barry Ryan of the Rollins School of Public Health of Emory University—tested air quality inside school buses in DeKalb County. We first recorded emissions from a typical bus on a regular bus route—a conventional bus run on regular #2 diesel fuel from the DeKalb County school bus fleet (hereafter referenced as the "conventional bus"). The same bus was then retrofitted and re-tested with a diesel particulate filter (DPF) and run on ultra-low sulfur diesel fuel (ULSD) (hereafter referenced as the "retrofitted bus"[37]).

Ulla-Britt Reeves

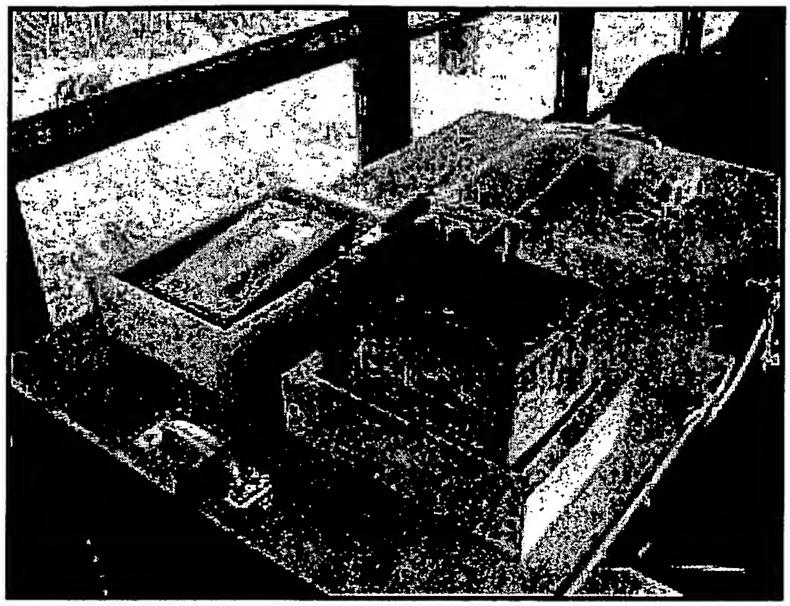
**Kids Against Pollution** ***(from left, Anthony Dorsey, Gregg Clarkson from MBC News, Niyoka Jordan , Melvin Morris, Illai Kenney)***

Diesel particulate filters (DPFs) are ceramic devices that collect particles as the exhaust gases pass through the filter. The heat from the exhaust allows the particles to break down into less harmful substances[38]. Ultra-low sulfur diesel fuel (ULSD) is diesel fuel with no more than 15 parts per million (ppm) of sulfur. This device was tested based on claims by manufacturer estimates that a DPF (which must operate in tandem with ULSD) can achieve a 70-98% reduction in particulate matter, hydrocarbons and carbon monoxide from the tailpipe[39].

**A diesel particulate filter is installed on a DeKalb County school bus.**

Our study had two primary goals. The first, which mirrored a number of earlier studies mentioned previously (EHHI 2002, CARB 2003), was to monitor and characterize the degree to which students are exposed inside the school bus to particulate matter (ultrafine particles, fine particles and black carbon) during their typical rides to and from school. In addition, our study identified and tested prospective means to control overall emission levels in the school bus cabin. The comparative approach of this study, a conventional bus versus a retrofitted bus, using a separate control vehicle, collecting real-time wind direction and weather data and measuring the concentrations of three pollutants, made it possible to detect multiple sources of emissions affecting air quality and human exposure levels inside the bus cabin.

In determining pollution levels, the study considered the following factors: bus engine age, operation and condition; window ventilation, idling and queuing behavior; ride duration and outdoor air quality. We measured ultrafine particles (less than $PM_{2.5}$), fine particles ($PM_{2.5}$), and black carbon (elemental carbon). We tested the buses under a range of operating conditions: single bus idling, three buses lined up end-to-end while idling ("queuing") and during a typical neighborhood route, including drop-off and pick-up ("bus rides"). Ultrafine particles were measured using a TSI Ptrak monitor in particles per cubic centimeter (particles/cc) of ambient air. $PM_{2.5}$ particles were measured using the TSI Dust Trak monitor and black carbon levels were measured with a Magee Scientific Aethalometer (see Appendix A for more detail on instrumentation). Both the lead car and the school bus were equipped with identical instrumentation.

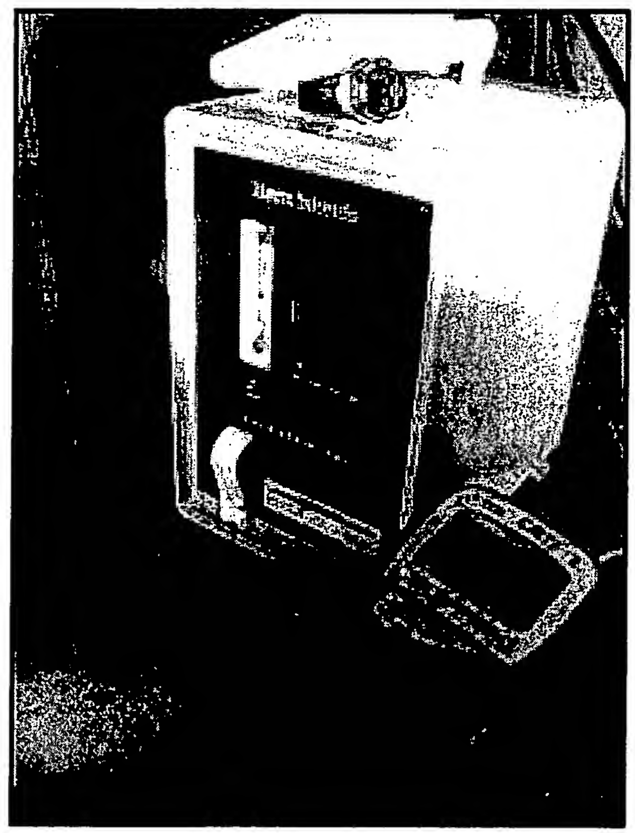


**The TSI Dust Trak monitor measured $PM_{2.5}$ particle concentrations inside the bus cabin.**

During bus route testing, a lead car drove in front of the bus to establish baseline levels in the outdoor air of the pollutants to be measured. Windows were rolled down in the car at all times to gauge concentrations of diesel exhaust from sources other than the bus that could potentially impact cabin air quality. We followed an actual school bus route used by the DeKalb County School System (see Appendix A for more detail). The route primarily ran through residential neighborhoods and thus came in contact with few or no external diesel sources during the testing except when crossing major roads to get to the neighborhoods. None of the school district students rode on the buses during testing.

The data reported in this paper reflect raw values from the instruments, with outdoor concentrations subtracted from the bus route data. Furthermore, it is important to note that the Dust Trak is calibrated with Arizona road dust and may therefore overestimate $PM_{2.5}$ levels by about a factor of two.

Appendix A provides a detailed description of the testing methods, equipment and technology controls used in the study. For additional detail on this study not included in this report, including results of companion studies conducted by the Clean Air Task Force and Purdue University in Ann Arbor, Michigan and Chicago, Illinois, go to: http://www.catf.us/goto/schoolbusreport/[40].



**The Aethalometer monitor (left) measured black carbon and the TSI Ptrak monitored (right) measured ultrafine particle concentrations inside the bus cabin.**

# Findings

## *General*

The results of our study clearly demonstrate that using available retrofit technology combined with ultra-low sulfur diesel fuel dramatically improves the air quality inside school buses. These technologies combined with other pollution reduction programs could significantly improve the quality of the air our children breathe and the quality of life for all Georgia citizens.

Results indicate that in-cabin pollution primarily arises from three sources: tailpipe emissions, engine crankcase emissions, and sources other than the bus itself. The in-cabin level of particulate matter over time is dictated by the amount of pollution from the various sources and outdoor wind conditions. For instance, with a strong wind blowing particles emitted by the tailpipe at the rear of the vehicle toward the open door at the front, cabin pollution levels increased markedly.

While the bus proceeded along its route (including stops at traffic lights and pick-up locations), pollution from the tailpipe or engine either built up or dropped depending on wind direction and velocity relative to the emissions sources at the bus stops when the door was open.

***Exhaust from the tailpipe and the engine crankcase entered through the front door of the buses.***

We found that a large percentage of the ultrafine particles recorded in the cabin of the conventional (non-retrofitted) bus had originated as tailpipe emissions in all three tests—idling, queuing, and driving on a bus route. After the bus had been retrofitted with a DPF and ULSD, however, ultrafine particles from the tailpipe dropped to the point of being undetectable in the cabin in all three testing scenarios.

## *Idle and Queue Tests*

The buses were tested for cabin pollution levels while idling and lined up end-to-end (queuing). During the 10-to-20-minute single idle tests, very little tailpipe exhaust entered the cabin presumably because the bus door and windows were sealed tightly. However, once the doors were opened, ultrafine and $PM_{2.5}$ levels rose rapidly and steadily depending on the wind direction relative to the bus door and emissions sources. Similarly, in queuing tests, where buses were parked closely end-to-end while idling, we recorded rapid buildup of all three emissions—ultrafine particles, $PM_{2.5}$ (Figure 1) and black carbon (Figure 2) when

**Emissions were measured inside the buses as they were lined up end-to-end (queuing) to simulate a typical drop off or pick up of children before or after school.**

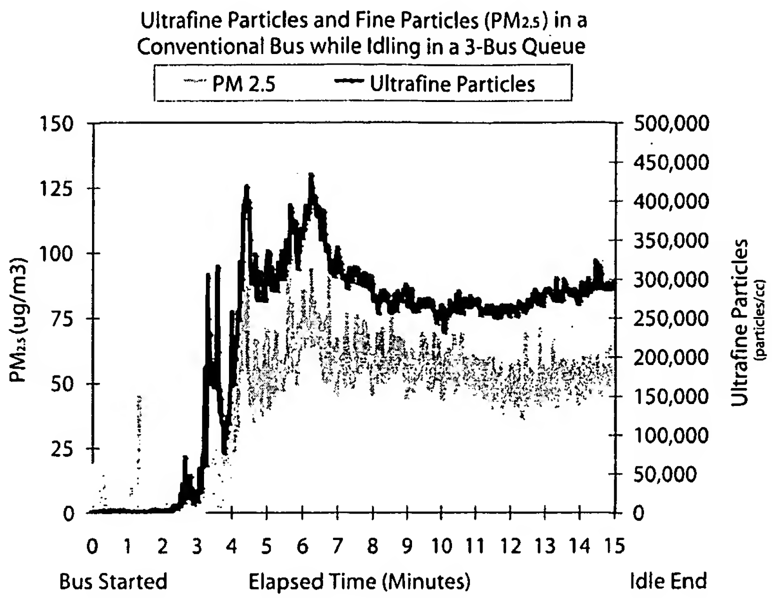



**Figure 1. Note: These are net concentrations—outdoor concentrations have been subtracted.**

the door was opened.

When the door of the middle bus in the line-up was opened as it idled—as frequently occurs in loading and unloading zones at schools—dramatic increases in ultrafine particles and $PM_{2.5}$ were observed within the first three to four minutes after the bus was started and remained elevated throughout the duration of the idle test.

***Dramatic increases in ultrafine particles and $PM_{2.5}$ were observed within the first three to four minutes after the bus was started.***

Black carbon levels of the conventional bus also increased during idling (Figure 2).

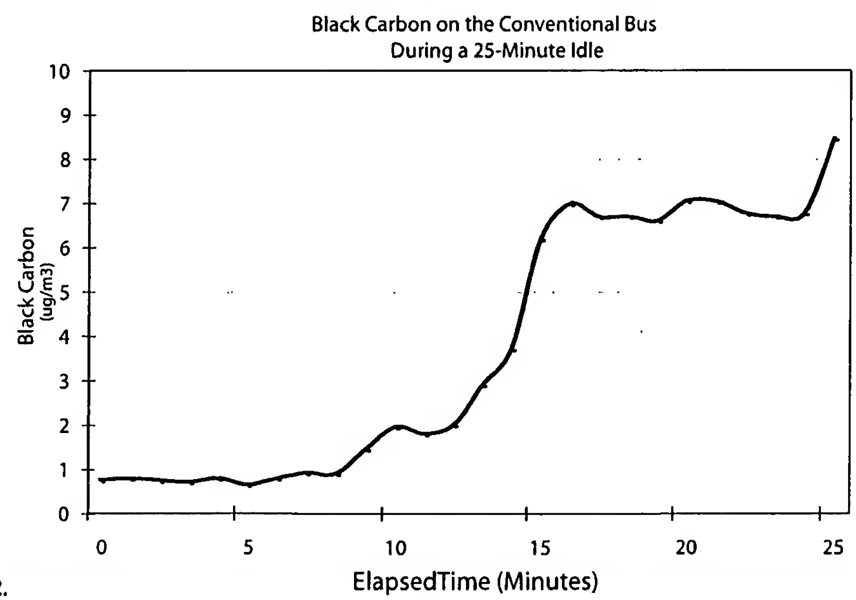



**Figure 2.**

Before the buses left on their morning routes, we also tested air quality outside at the depot where buses are stored and maintained. Fine particle ($PM_{2.5}$) concentrations jumped significantly when the buses were started (Figure 3). Several of the buses were started 10-20 minutes before departure and idled consistently until their departure. During morning idling, particle concentrations increased significantly inside the bus before departure. When the buses left the depot to begin their pick-up routes, interior levels of all three particle-types—ultrafine particles, $PM_{2.5}$, and black carbon—were already high.

***During morning idling, particle concentrations increased significantly inside the bus before departure.***

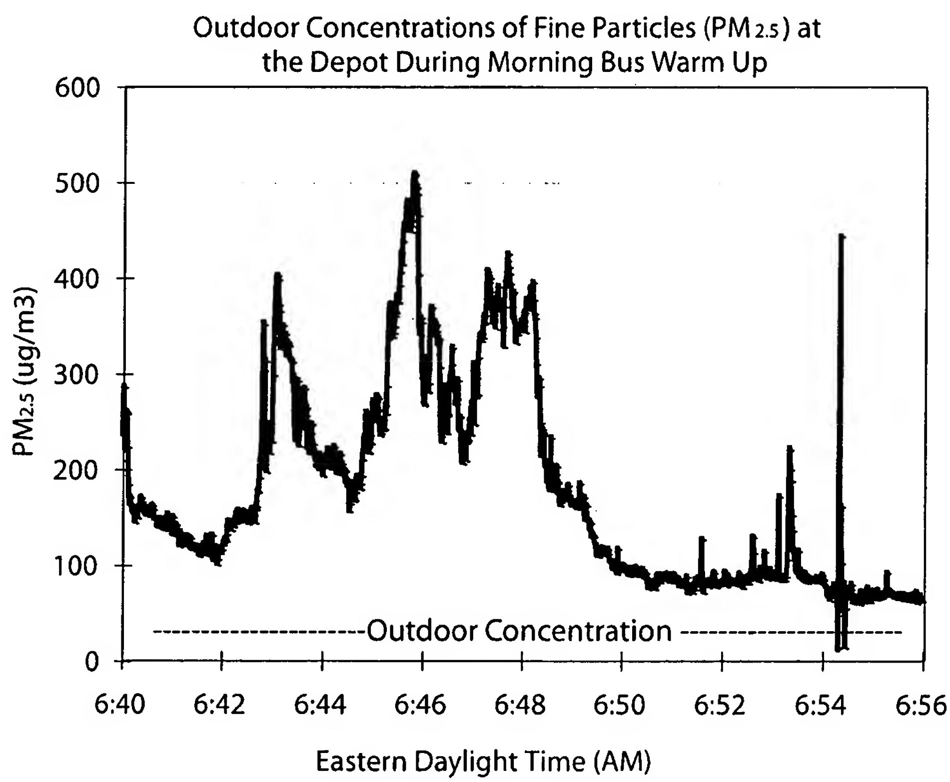



**Figure 3.**

Results of the idling and queuing tests indicate increased levels of ultrafines, $PM_{2.5}$ and black carbon on conventional buses. In comparison, during a ten (10) minute idle test on the retrofitted bus, ultrafine particles concentrations were reduced to outdoor concentrations or slightly below (Figure 4)[41].

All idle and queue test comparisons—conventional versus the retrofitted bus—demonstrated that the diesel particulate filter in combination with ultra-low sulfur diesel fuel reduces ultrafine particles in the bus cabin.

***The diesel particulate filter in combination with ultra-low sulfur diesel fuel was found to significantly reduce ultrafine particles in the bus cabin.***

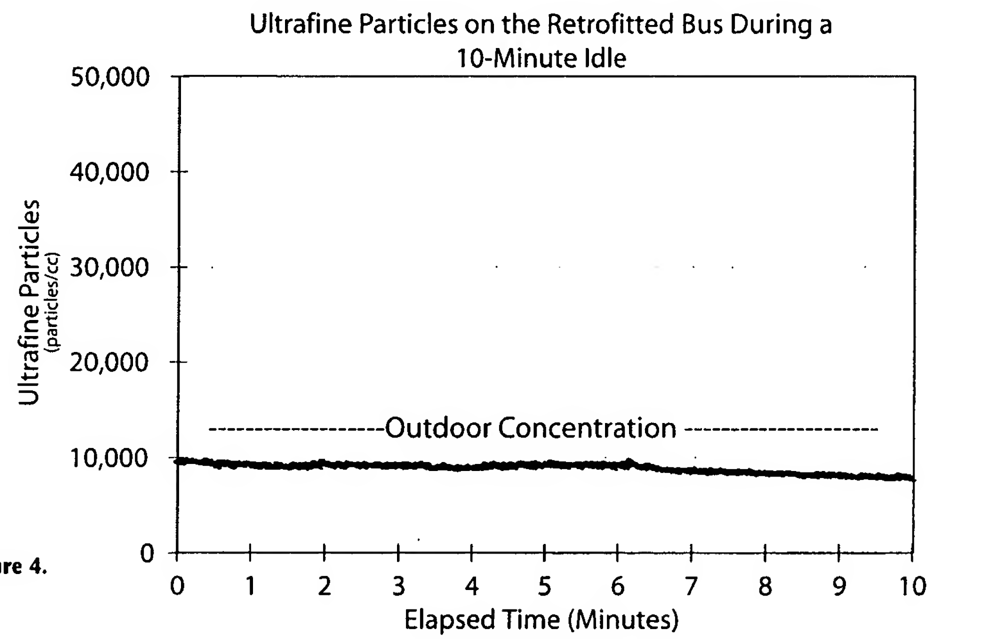



Figure 4.

## *Pick up and Drop off Demonstration*

We monitored changes in curbside air quality near a bus in which the driver simulated picking up or dropping off a student. The intention was to assess the effect of bus emissions on air quality near a pick-up or drop-off point at a school or bus stop. In this demonstration, illustrated in Figures 5 and 5.1, particle monitors outside the bus measured air quality levels as the conventional and retrofitted buses passed the monitor. We recorded sharp spikes in levels of ultrafine particles as the conventional bus drove up, stopped, opened its door, shut

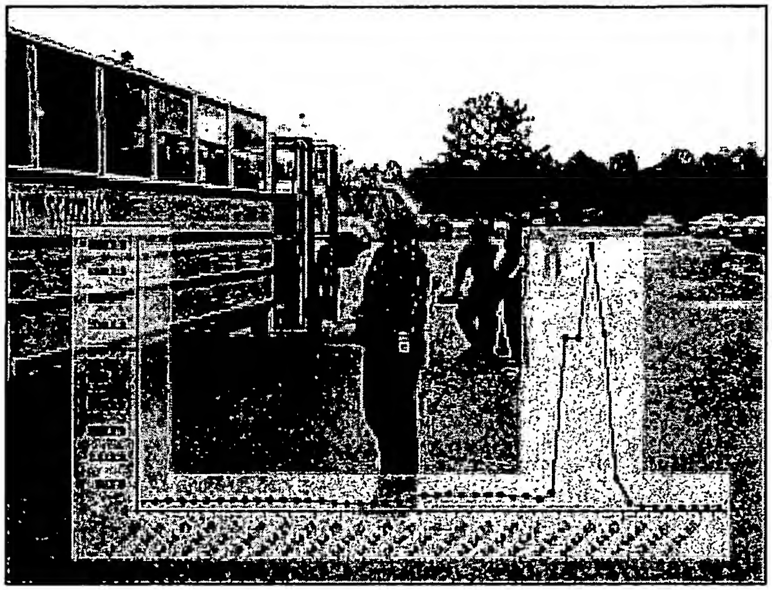


**Figure 5. This image is an overlay of the bus movement with monitor measurements of ultrafine particle levels outside the conventional bus. The line indicates the spike of ultrafine particle levels on the monitor at the same time the tailpipe passed the monitor.**

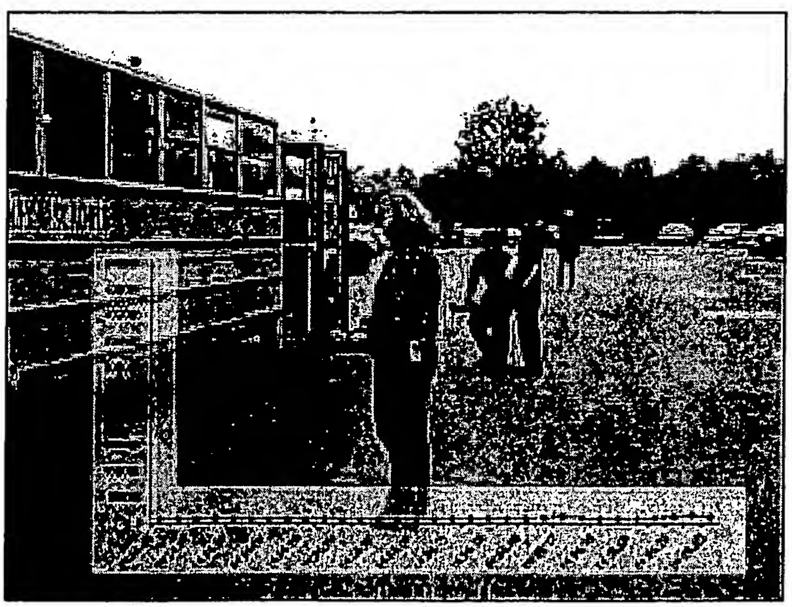


**Figure 5.1. This image is an overlay of the bus movement with the monitor measurements of ultrafine particles on the retrofitted bus. In contrast to Figure 5, the ultrafine particle levels remained at the low outdoor levels at the same time the tailpipe passed the monitor.**

the door, and drove away. When the retrofitted bus performed the same sequence of events, the ultrafine particles were virtually nonexistent (see Figures 5 and 5.1).

## *Bus Ride Tests*

We found that diesel particulate matter routinely entered through the front door of the conventional bus and into its cabin. When the door was opened at each bus stop, particulate matter concentrations typically increased. As the bus proceeded along its route, interior particulate matter levels continued to build up until they were many times higher than ambient levels; conversely, in cases where local winds blew emissions away from the open door at the bus stops, interior particulate matter levels then held steady or declined as the bus resumed its route.

Conversely, as shown in Figure 6, bus tailpipe emissions were undetectable inside the cabin of the retrofitted bus during the bus ride tests. Measurements indicated that ultrafine particle concentrations remained close to outdoor ambient levels during the entire ride, with the exception of a few concentrated external sources in the roadway.

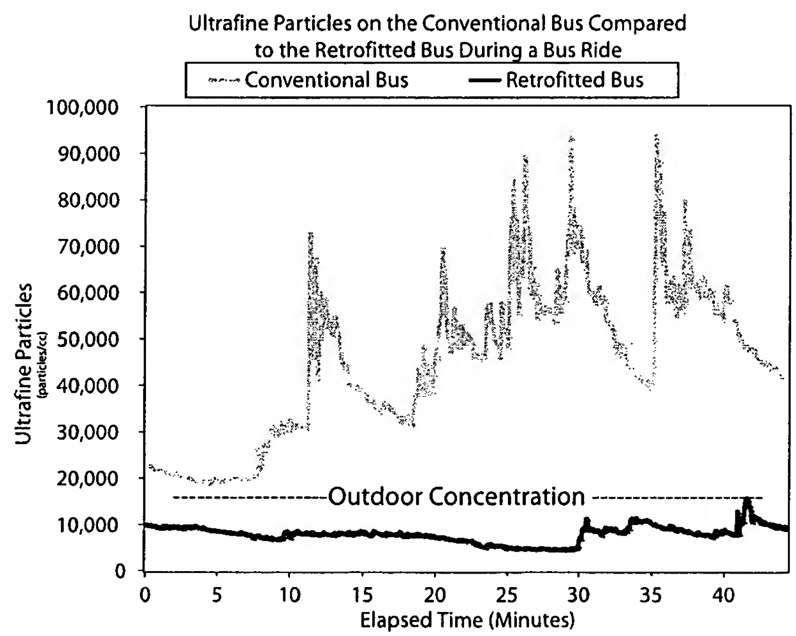



**Figure 6.**

As mentioned previously, instruments in the lead vehicle measured outdoor conditions. This control was used to identify whether or not exhaust from other vehicles in the roadway contributed to emissions inside the bus. We found that the particulate matter concentrations in the retrofitted bus were rarely impacted by outdoor sources in the residential neighborhoods along the bus route unless they were exceedingly concentrated by another truck or transit bus in front of or adjacent to the bus. As shown in Figure 7, ultrafine particle concentrations inside the retrofitted bus remained minimal while the lead car detected

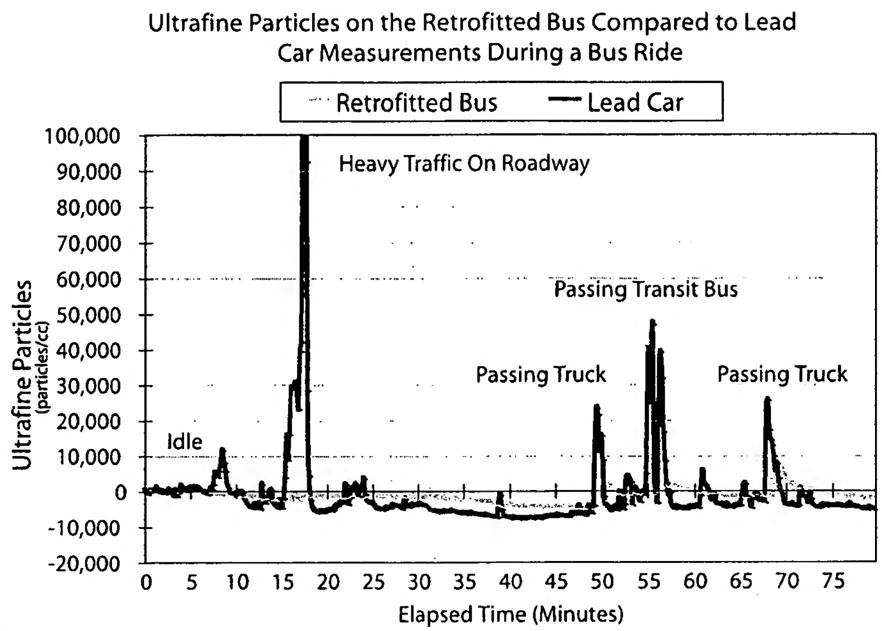



**Figure 7.**

elevated levels of ultrafine particles in the roadway in front of the bus. This supports evidence that the buses' own emissions pollute the cabin rather than the external sources.

Conversely, in residential areas, after ventilation of the retrofitted bus, $PM_{2.5}$ concentrations were still building up at stops suggesting continuous bus self-pollution as monitors in the lead car recorded little $PM_{2.5}$ in the roadway in front of the bus. This observation eliminated the roadway as a source of in-cabin pollution (Figure 8). Observations therefore suggest a source other than the tailpipe of the retrofitted bus or external sources. After investigating the engine compartment we observed smoke emissions from a crankcase ventilation tube under the hood, relatively close to the bus door. Smoke from this source was observed blowing in the bus door and causing sharp increases in $PM_{2.5}$. Therefore, we conclude that the retrofitted bus was not significantly affected by other emissions on the bus route or from the tailpipe, but that $PM_{2.5}$ levels inside the bus cabin emanated directly from the engine crankcase despite the retrofitted tailpipe.

Bus windows were kept closed during most of the testing in order to ensure minimal impacts from outside diesel sources. However, when measurements were taken with the windows open, there were short-term spikes in particulate matter levels in the bus cabin. When the windows were left open for longer periods, allowing the bus to ventilate, the particulate matter levels in the cabin decreased. With the windows closed, however, the ventilation rate was slow, so emissions built up inside the cabin. We recognize that during normal bus operations, there will be greater variability in particulate matter concentrations inside the cabin due to changing window configurations associated with varying outside temperatures and bus rules. To help identify particulate matter sources and concentrations during simulated rides, buses were ventilated between trips, with the result that interior levels of particulate matter were the same as the levels in the outdoor air when starting a testing session.

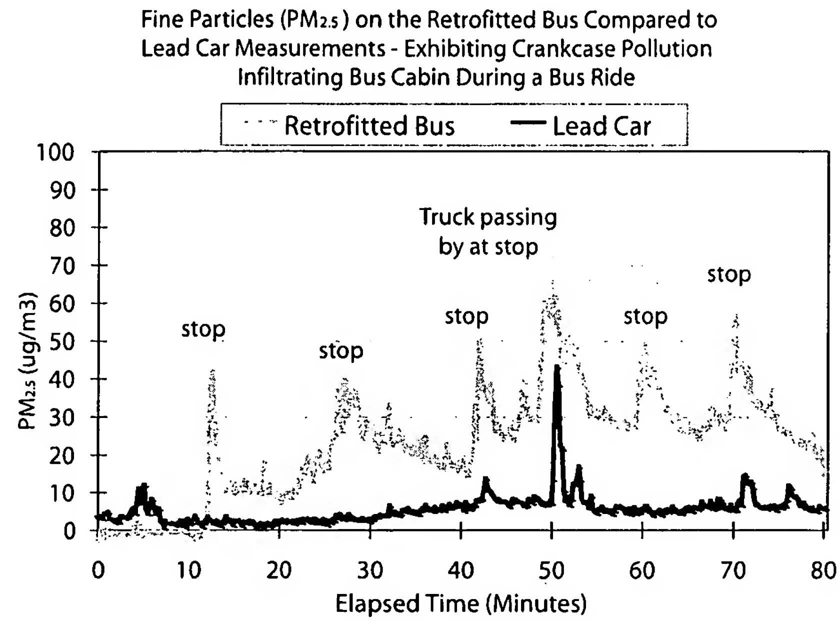
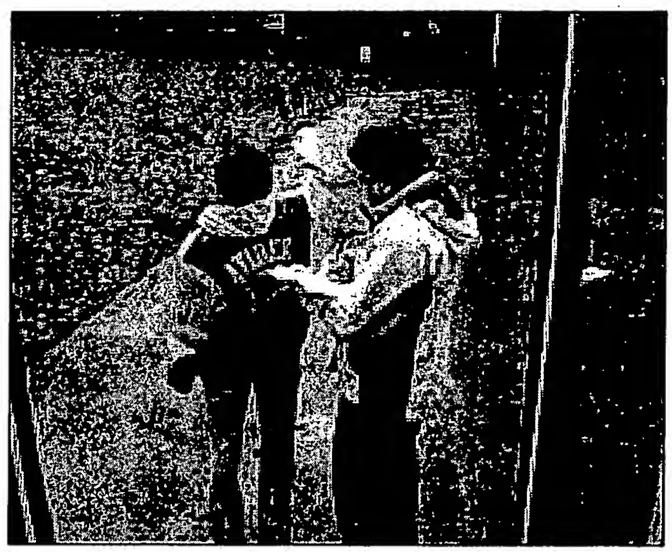



**Figure 8.**

Wind speed and direction relative to the bus were measured outside the loading door at each stop. These measurements helped to identify the source of the different exhaust particles. Wind from the back of the bus generally correlated with emissions of ultrafine particles from the tailpipe and wind from the driver's side of the bus correlated with emissions of $PM_{2.5}$ from the engine crankcase.

Concentrations of ultrafine particles declined to outdoor levels or below in the cabin of the retrofitted bus in all tests, however concentrations of $PM_{2.5}$ remained elevated. $PM_{2.5}$ levels on the retrofitted bus and the conventional bus were similar—indicating that the diesel particulate filter did not eliminate $PM_{2.5}$ in the bus cabin. The correlation of elevated $PM_{2.5}$ levels with wind from the driver's side front of the bus revealed that these particles are emitted not by the tailpipe, but off the engine, thus supporting the observations in the retrofitted bus described above. Prior to the Clean Air Task Force and partners' school bus testing, of which this was the second city tested, the significant contribution of the engine crankcase to $PM_{2.5}$ concentrations in the bus cabin was undocumented.



**Researcher Anne Gilliam and Kids Against Pollution student Niyoka Jordan record wind speed and direction relative to the bus, and temperature at a bus stop.**

# Results of the Sister Study conducted in Ann Arbor, Michigan

Although the DPF eliminated ultrafine particles, $PM_{2.5}$ levels remained high inside the retrofitted bus with little to no change in these concentrations compared to the conventional bus. The minimal impact of the DPF on $PM_{2.5}$ levels inside the retrofitted bus was further confirmed by the low concentrations measured in the lead car. These results indicate that not all of the $PM_{2.5}$ pollution inside the bus is emitted by the tailpipe but from another source—the engine crankcase.

An inexpensive retrofit, the Donaldson Spiracle™ Crankcase Ventilation System (Spiracle™), as well as a few others, are now available to control this emission source. The Spiracle™ was not tested in the Atlanta study, but was tested in a follow up study by the Clean Air Task Force and partners in Ann Arbor, Michigan in October 2004. In addition to testing a bus retrofitted with the Spiracle™ and run on ULSD, tests were all also conducted to measure emissions levels on a conventional bus run on ULSD, and on a bus retrofitted with both a DPF and the Spiracle™ (DPF/Spiracle™) and run on ULSD. The testing methods were similar to the Atlanta study.

***The engine crankcase $PM_{2.5}$ emissions were found to significantly contribute to inside cabin air pollution even after the bus's tail-pipe was retrofitted.***

In the Ann Arbor study, the Spiracle™ alone completely eliminated all measurable $PM_{2.5}$ self-pollution inside the cabin (Figure 9)[42].

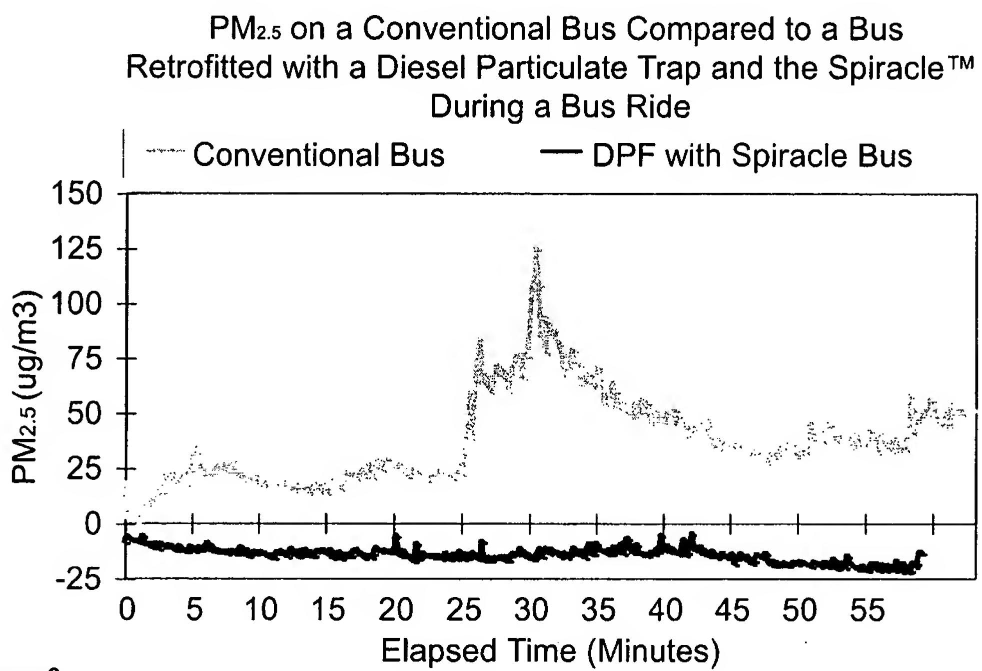



**Figure 9.**

As shown in Figure 9, the Ann Arbor study results indicate that with the DPF and the Spiracle™retrofits together, the bus is virtually eliminated of all measurable particulate matter self-pollution inside the bus cabin; the DPF eliminated ultrafine particles emitted from the tailpipe and the Spiracle™ eliminated $PM_{2.5}$ from the engine crankcase.

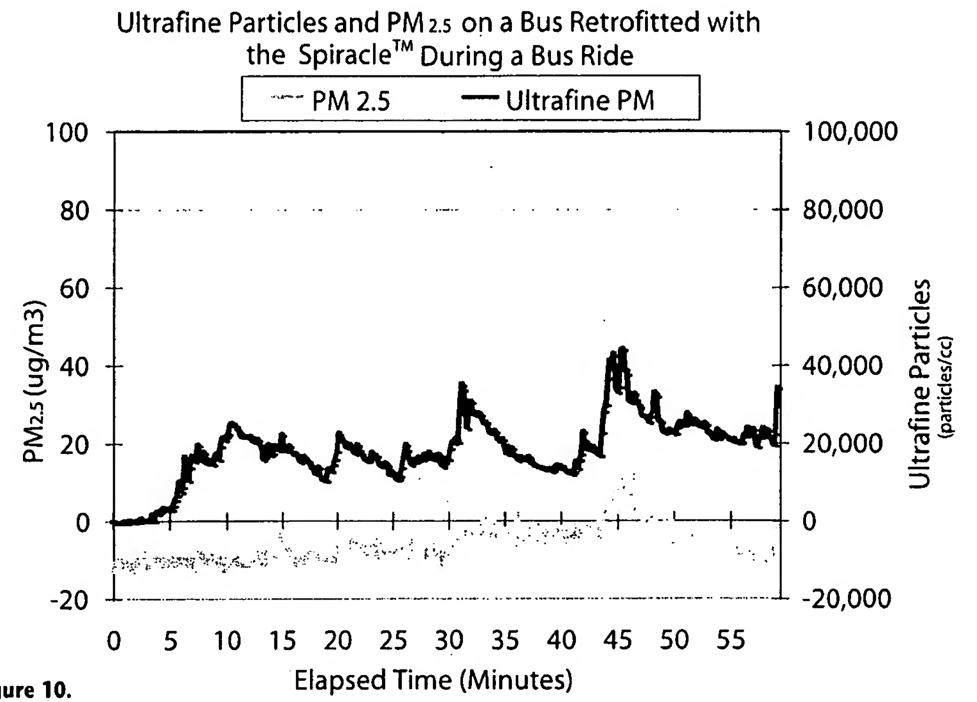



**Figure 10.**

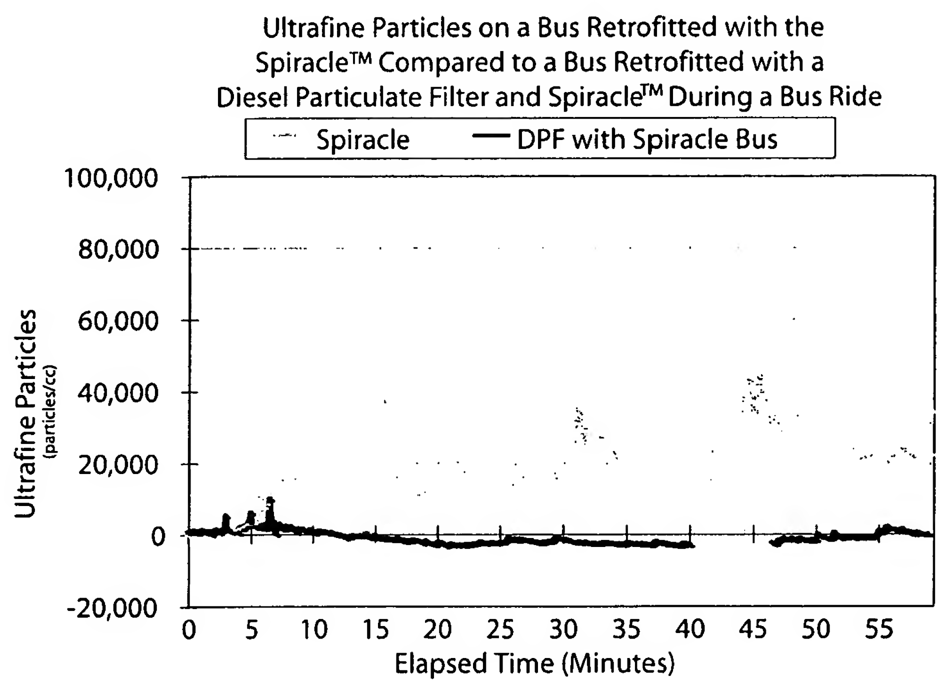



**Figure 11.** ***Note:* Five minute gap in data resulted from battery change required during testing.**

Based on all tests conducted in Atlanta and Ann Arbor studies, we conclude that a bus retrofitted with both a DPF and the Spiracle™ is the only retrofit combination that eliminates ultrafines, $PM_{2.5}$ and black carbon inside the cabin and is the most effective solution to clean up our buses and protect our children's health.

In conclusion, the diesel particulate filter (DPF), combined with ultra-low sulfur diesel fuel, effectively eliminated all detectable ultrafine particles emitted from the tailpipe. However, the filter and fuel had no measurable impact on $PM_{2.5}$ concentrations on board the bus, presumably due to the fact that the engine crankcase is blowing high, uncontrolled levels of $PM_{2.5}$ into the bus cabin. It appeared through the course of our study that these particles blew directly from the engine crankcase vent tube and into the cabin door when it was opened at the bus stops.

## *Key Findings:*

- Diesel particulate filters, in combination with ultra-low sulfur diesel fuel, eliminated the detectable ultrafine particles and black carbon from the tailpipe.

- Levels of ultrafine particles in the lead car when driving behind the tailpipe of the conventional uncontrolled bus were very high, and in many instances were off the monitor scale. With the DPF and ultra-low sulfur diesel fuel, the air measured in a car directly behind the bus detected no diesel emissions.

- The diesel particulate filter with ULSD did not eliminate $PM_{2.5}$ in the bus cabin as the $PM_{2.5}$ was shown to be coming largely from the engine crankcase.

- A follow-up study in Ann Arbor, Michigan showed that the Spiracle™ effectively eliminated the $PM_{2.5}$ in the cabin of the bus.

- The combination of the DPF and ultra-low sulfur diesel fuel with the Spiracle™ eliminated all measurable particulate matter-related self-pollution inside the cabin of the bus.

- The concentration of emissions penetrating the bus depended on wind speed and direction relative to the bus door during a pick up or drop off.

- Emissions typically entered through the door at the front of the bus.

- No statistical correlation was found between emissions in the roadway in front of the bus, as measured in the lead car, and changes in cabin air quality, largely because there were few nearby diesel emissions sources, except those encountered while coming and going to the bus route on major roadways, intersections, and highways.

- Buses typically ventilated themselves, even with the windows up, and exhaust levels in the buses declined as the buses proceeded between long stops.

- $PM_{2.5}$ levels inside the buses ranged from 2-5 times higher than outdoor levels, depending on the ambient conditions and conditions that affect cabin air quality, such as wind direction.

## *Idling Reduction*

**Anti-idling measures are inexpensive ways to reduce the daily exposures of school bus diesel exhaust to students and save money on fuel. Anti-idling policies should be adopted at the school, county, and state levels.**

As our study shows, when buses idle, students are often exposed to high levels of diesel exhaust inside the cabin within three minutes from the time the bus is started. Additionally, idling buses increase pollution in outdoor waiting areas where children, parents, and teachers gather for their rides. Pollutants emitted outdoors, including diesel exhaust from idling buses, also contribute to poor indoor air quality.[43] Bus loading and unloading zones are typically located in front of the schools directly adjacent to school entrances. As a result, exhaust from a line of idling buses can penetrate into school buildings and classrooms through doors, windows, and ventilation systems. Unfortunately, indoor air quality and air quality inside school buses is not currently regulated in the U.S.[44]

In order to prevent build-up of diesel exhaust both on and off buses, school officials should require bus drivers and waiting parents to turn off their engines when the vehicles are not in motion outside the school. Often, drivers start their engines well in advance of departure in efforts to warm or cool buses, contributing to dramatic increases in cabin pollution levels. According to U.S. EPA, typical school buses burn approximately one-half of a gallon of diesel fuel for each hour of idling[45]. Fortunately, simple, cost-effective strategies can be implemented to manage idling pollution and still provide heating and cooling for buses. Auxiliary power units can be added to buses to allow the use of lighting and provide cooling and heating while the buses are parked without running their engines. This study shows that the bus cabin air quality will be substantially improved if doors and windows are closed prior to start-up. Leaving buses off can be motivated by providing bus drivers with a warm or cooled area indoors to wait in the winter or summer, rather than on an idling bus.

***Regulations do not currently exist in the U.S. to monitor indoor air quality or air quality inside school buses.***

In addition, a school anti-idling policy should require all other diesel equipment, including construction and delivery vehicles, operated on school property, to turn off their engines when not in motion. Anti-idling measures will reduce children, family, bus driver, and school staff exposure to diesel exhaust. They will save schools thousands of dollars a year in fuel and maintenance costs from reduced fuel consumption and wear and tear on the buses and equipment.

***Idling policies and programs are win-win strategies—they protect student health by reducing exposure and save the school systems money by reducing fuel consumption and engine wear and tear.***

Anti-idling ordinances and laws should also be established at the city and state levels in an effort to strengthen school policies. More than twenty states have adopted anti-idling regulations for all types of diesel engines. Most limit idling time to five minutes or less for trucks and buses. The City of Atlanta adopted an idling policy in April 2003. Unfortunately, the ordinance is broad and allows school buses to idle up to twenty-five (25)

minutes[46]. As demonstrated in our study, particulate matter concentrations will build up rapidly (much sooner than 25 minutes) inside the bus cabin when the bus is idling. The city's policy clearly does not require the protection needed to reduce the health impacts to children from pollution build-up while idling.

The most challenging hurdle with idling regulations is appropriate enforcement and driver education. Idling regulations should include shared enforcement components between environmental regulators, local enforcement, parents, teachers, kids, local citizens, and school officials. Regulations should include supplemental local policies, such as a Memorandums of Understanding (MOUs) or written agreements between schools and the city or county to reduce idling and provide enforcement. To encourage idling reduction and management, fleet managers and transportation supervisors should consider providing rewards and incentives to bus drivers who exhibit protective behavior and stop idling.

**Massachusetts state law prohibits idling for more than five minutes.**

## *Retrofits*

**Diesel particulate filters (DPFs), in combination with ultra-low sulfur diesel fuel (ULSD), is an extremely effective solution to reduce ultra-fine particles in the cabin of school buses and diesel exhaust concentrations in the roadway.**

By using cost-effective retrofit equipment that is available today, reductions of up to 90 percent in $PM_{2.5}$ emissions from existing diesel engines could be achieved by the end of the decade. In fact, our study shows that a DPF will eliminate ultrafine particles and black carbon self-pollution in the cabins of buses. Retrofitting can include the repowering or rebuilding of an engine, but most commonly the term refers to the use of after-market pollution control technologies (retrofits).

Buses manufactured between 1990 and 2004 can be effectively cleaned up with the use of pollution control devices like the DPF and cleaner fuels. While our study results conclude that DPFs and crankcase filtration systems are the best retrofit combination, certain older engine types and model year buses are unable to use the new technologies.

For these older buses that cannot be immediately replaced and that are not electronically controlled or do not meet the high temperature requirements, which are necessary for DPF use, school districts should investigate alternative retrofit and fuel options and costs for each type of bus in the fleet.

Diesel oxidation catalysts (DOCs) can be used with additional pollution control devices in order to provide some pollution reduction benefits. DOCs are less expensive, but according to manufacturers and U.S. EPA, they only reduce fine particles between 20-30 percent[47,48]. DOCs can be used with crankcase filtration systems, such as the Spiracle™, to achieve further reductions. Retrofitting existing diesel engines will provide reductions far earlier than those promised by recently adopted federal regulations for highway and off-road diesel engines.

**Eliminating $PM_{2.5}$ from the engine crankcase using a device called the Spiracle™, to**

**reroute pollution from the crankcase back into the engine is the only retrofit, if used in combination with the DPF, that eliminates both ultrafine particles and $PM_{2.5}$ self-pollution inside the bus cabin.**

Crankcase filtration systems are relatively inexpensive, approximately $450 per device plus a half day of installation time, and will help reduce emissions, particularly $PM_{2.5}$, emanating from the engine crankcase[49].

## *Inspection and Maintenance and Accelerated Replacement*

**School officials should incorporate inspection and maintenance programs into their transportation plans and budgets. Inspection and maintenance programs ensure that school buses are free of severe mechanical problems and allow them to be addressed in a timely manner.**

Neither Georgia state nor federal law requires the routine emissions testing of school buses. Nonetheless, such testing—backed by inspection and maintenance programs—are important and effective ways to maintain clean diesel engines and minimize health risk.

Requiring routine maintenance ensures that buses run smoothly, efficiently, and prevents problems with leaking fumes, soot, fuel, or oil. There are sixteen (16) programs currently in operation throughout the U.S. for heavy-duty diesel vehicles[50]. No such program currently exists for these vehicles in Georgia.

**Accelerate replacement or rebuild of older diesel engines—equip or rebuild engines with the most advanced emission control systems available. Running newer, cleaner buses ensures that our children are not exposed to high levels of diesel exhaust.**

School administrators and transportation directors must take the initiative to address diesel pollution. ***Vehicles built prior to 1990 are still on the road today, and they emit more than six times more nitrogen oxides, particulate matter and hydrocarbons than newer models.*** In Georgia, 36.1% of the school buses were built between 1977 and 1990[51]. Most school systems in Georgia operate buses between ten and fifteen years before replacing them. Operating older buses means that these engines will continue to emit harmful pollutants until they are retired. These older engines should be immediately replaced.

## *Additional Recommendations*

- Require all *existing* diesel vehicles (2007 and older model year vehicles) purchased and used in school-related projects to meet the federal 2007 on-road and non-road diesel standards;
- Require only retrofitted diesel engines using ultra-low sulfur diesel fuel or alternative fuels to be used in school construction projects;
- Require anti-idling control measures for all diesel equipment, including construction and delivery vehicles, on or operated on school property.

One of the biggest challenges often cited for retrofitting buses is the cost. The DeKalb County School System operates more than 1,100 buses and transports 78,000 students to and from school every day[52]. For DeKalb County School System, it would potentially cost more than $7.7 million to install diesel particulate filters, excluding the cost of ultra-low sulfur fuel, which must be used with DPFs. It is estimated that ULSD will be 5-10 cents more per gallon of fuel than diesel fuel available in Georgia today. So, where and how can schools afford to do this? The answer is not simple. But we must ask what is our air quality worth in dollar-equivalents? Many school districts and states throughout the country are recognizing the enormous health and nonattainment benefits of these technologies and are developing funding programs and initiatives to address this problem.

## *National Funding Programs for School Buses*

**The Environmental Protection Agency's Clean School Bus USA[53]**
First initiated in 2003, the Clean School Bus USA program, sponsored by the U.S. Environmental Protection Agency (U.S. E.P.A), focuses on reducing the amount of pollution emitted from diesel school buses and children's exposure to diesel exhaust.

There are three primary goals of the program:

1. *Eliminate unnecessary public school bus idling.*
2. *Retrofit buses with emissions control technologies.*
3. *Replace the oldest school buses in the fleet with new, cleaner school buses.*

In the first year of the program, EPA awarded funding for seventeen (17) demonstration projects throughout the U.S. The projects are anticipated to reduce pollution from about 4,000 buses and remove over 200,000 pounds of diesel particulate matter from the air over the next ten years. In 2004, EPA awarded twenty grants, totaling $5 million. These twenty projects will address pollution from over 5,000 school buses across the nation.

In July 2004, the Georgia Environmental Protection Division received a grant of $490,000 through this program to develop an Adopt-A-School Bus program. The money will be used to retrofit buses for four Georgia school districts. More information on this program can be found at www.adoptaschoolbusgeorgia.com.

**The Environmental Protection Agency's Voluntary Diesel Retrofit Program[54]**
This program focuses on reducing pollution from existing diesel vehicles from all sectors—both on-road and non-road. Through the program, fleet owners are encouraged to install pollution control devices on the vehicles and to use cleaner-burning diesel fuel. More than twenty-eight projects have been funded through this program across the U.S.

Though this program focuses on the clean-up of both on-road and off-road vehicles, here in the Southeast, the Chattanooga-Hamilton County Air District in Chattanooga, TN was awarded $100,000 to fund a public/private partnership retrofit project that will equip eighty-three (83) school buses with diesel oxidation catalysts.

**Clean Buses for Kids School Bus Diesel Retrofit Program[55]**
This program provides funds to school districts to purchase and install emission control

equipment and ultra-low sulfur diesel fuel to reduce diesel particulate emissions from school buses. The funds have been made available as the result of a settlement of an enforcement action against Toyota Motor Corporation by the U.S. Environmental Protection Agency under the Clean Air Act. Awards from $30,000 to $750,000 will be available per entity.

Public school districts and government entities that own and operate a diesel school bus fleet are eligible for the funding. Preference will be given to school districts located in non-attainment areas for fine particles ($PM_{2.5}$) or for the 8-hour ozone standard.

## *Georgia Can Do More to Protect Our Children's Health*

Unfortunately, the allocated funding available through the aforementioned programs is not enough to finance the clean-up of all the existing diesel school buses and other diesel engines in the marketplace today that are unaffected by the new federal regulations. Budget cuts and inadequate education are preventing school systems from running cleaner buses and reducing the impact of these emissions on our children and bus drivers.

To more effectively address this financial problem and promote retrofits for existing engines, EPA and several state partnerships have developed assistance and educational programs. Little has been done in Georgia to provide adequate funding for diesel clean-up. We recommend that our local and state air districts, planners, organizations, fleets and manufacturers work together with us to develop permanent regional or state funding mechanisms and incentives to assist with the clean-up of these heavy-duty diesel engines and reduce the impacts of these engines on the region's air quality and our children's health.

EPA and researchers have confirmed that diesel emissions are a critical health risk. With the proven benefits of the diesel pollution control technologies demonstrated in our study and the availability of proven pollution control technologies on the market today, we know that providing our children a *safer* and *cleaner* ride to school is completely achievable and is up to us!


**Harland Boys and Girls Club students, Atlanta, GA**

# Appendix A

## *Methods*

The methodology for this study is fully explained in a Clean Air Task Force report available on the web at http://www.catf.us/goto/schoolbusreport/. The following is a synopsis of methods used in the Atlanta study.

DeKalb County School System provided the buses for the study. The fleet managers identified and provided "typical" age, mid-mileage, relatively new conventional buses. Buses were inspected to ensure that they were generally characteristic of the fleet and that the rear doors and windows were adequately sealed and shut tightly.

The bus tested with and without retrofits was a 1999 International 446 (rebuilt from a 444E) engine with 70,637 miles. A 1999 International 446 bus with 46,723 miles was also tested. The buses for testing were selected by the fleet manager and transportation director with the DeKalb County School System. The DPF was an International Truck and Engine product and the ULSD fuel was provided by Nalley Bus Group of Atlanta.

Ultrafine particles are 0.01 or smaller microns in size (a micron is a millionth of a meter). They are comparable in size to some viruses and bacteria. These particles were measured using a TSI Ptrak in particles per cubic centimeter (particles/cc) of ambient air. Ptrak data was collected in 1.0-second intervals.

$PM_{2.5}$ particles are those particles 2.5 microns or 2.5 millionths in diameter. These particles are less than one-hundredth the width of a human hair. These particles were measured using the TSI Dust Trak, a continuous $PM_{2.5}$ mass monitor with a Nafion tube diffusion dryer to eliminate the potential effect of humidity on the particle measurements. The data was collected in 1.0-second intervals with a 10.0 second time constant. Because the Dust Trak is calibrated with Arizona road dust combustion-related $PM_{2.5}$ levels may be overestimated by an approximate factor of two.

Black (elemental) carbon levels were measured with a Magee Scientific Aethalometer with a BGI Inc. $PM_{2.5}$ cyclone.

The Dust Trak monitor was located in the middle of the bus, level with the top of the seat backs, and the Ptrak and Aethalometer were situated at seat level. All measurements were made with the windows tightly closed in the bus to reduce the effects of external vehicle pollution in front of the bus.

A Sony DV-Cam digital video camera was used to document traffic conditions and air quality conditions during the study. The camera was used to record bus run activities inside the cabin and other roadway activities related to the lead car, volunteers, etc. The camera was useful in documenting emissions sources, such as from underneath the bus, from the engine crankcase, blowing into the bus or from the tailpipe.

## *Retrofit Emission Reduction Charts*[56]

Below is a list of some of the retrofits currently available and the estimated tailpipe emissions reductions potential. Some of the retrofits can only be run with Ultra-Low Sulfur Diesel Fuel (ULSD). Unfortunately, ULSD is not currently available in the Southeast, but efforts are underway to bring ULSD to the Southeast in late 2004. The availability of ULSD will enable these technologies to be installed on existing engines and begin reducing harmful pollutants. The applicability of the various retrofits is dependent on a number of factors, including engine temperature, engine type and load, and drive cycle. All transportation directors, fleet managers, and mechanics should consult directly with manufacturers and conduct real-life condition/use tests before purchasing equipment.

Using regular diesel fuel, the following reductions can be achieved with the listed technologies:

| Control | PM | NOx | CO | HCs | Approximate Cost/Unit |
|---|---|---|---|---|---|
| Diesel Oxidation Catalyst (DOC) | 20-30% | | 70% | 70% | $1,000-$2,000 |
| Crankcase Filtration System | Data available only for combo of DPFs and DOCs | | | | $300-700 |
| DOC and Crankcase Filtration System | 25-50% | | | | $1,900 |
| Fuel Borne Catalyst | 15-30% | | | | A few cents/gallon |
| Fuel Borne Catalyst w/DOC | 40% | | | | $1,000-$2,000 +.FBC cost |
| Wire Mesh DOC, flow through filter (ESW) | 35-70% | | 70% | 70% | $1,500-$3,500 |

With the use of ULSD, it is estimated that the following reductions can be achieved with the listed technologies:

| Control | PM | NOx | CO | HCs | Approximate Cost/Unit |
|---|---|---|---|---|---|
| Use of ULSD-no control device | 5-10% | | | | 5-20 additional cost over regular #2 diesel |
| Diesel Particulate Filter | 60-90% | | 60-90% | 60-90% | $5,000-$10,000 |
| Diesel Oxidation Catalyst (DOC) | 25-50% | | 90% | 70% | $1,000-$2,000 |
| Diesel Particulate Filter w/DOC | 60-90% | | 90% | 90% | $6,000-$12,000 |
| DPF and Crankcase Filtration System | 80-90% | | 90% | 90% | $5,300-$10,500 |
| Exhaust Gas Recirculation (EGR) | ++++ | 40% | | | $13,000-$15,000 |
| Selective Catalytic Reduction (SCR) | 30-50% | 60-90% | 50-90% | 50-90% | $10.000-$50,000 |
| NOx Adsorber | | 70-90% | | | $10,000-$50,000 |
| Diesel Particulate Filter with Selective Catalytic Reduction | 90% | 75-90% | | | $5,000-$10,000 |
| Fuel Borne Catalyst w/DOC and ULSD | 50% | | | | |
| Fuel Borne Catalyst with DPF and ULSD | 85% | | | | |
| Diesel Particulate Filter with Exhaust Gas Recirculation | 90% | 40% | | | |

## POLLUTANT KEY

**PM** — Particulate Matter
**CO** — Carbon Monoxide
**NOx** — Nitrogen Oxides
**HCs** — Hydrocarbons

# Endnotes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# Heavy Duty Diesel Engine Consent Decree Documents

Ex. F

**Motion to Enter Informa**

The Motions to Enter the st the diesel engine manufacturers were filed District of Columbia by the Departme ... 1999. Each Motion to Enter contains comments made to the Court regarding the consent decree, the United States' response and grounds made by the United States on why the Court should enter the consent decrees. All the Motions are identical except the one for United States v. Navistar International Transportation Company.

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- Caterpillar Inc.
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